

SPECIAL ISSUE: THE YEAR IN SCIENCE

Discover

THE WORLD OF SCIENCE

JANUARY 1998

19
97

THE TOP

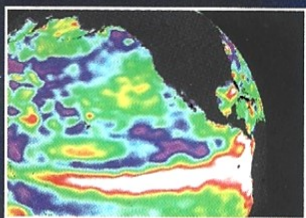
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SCIENCE

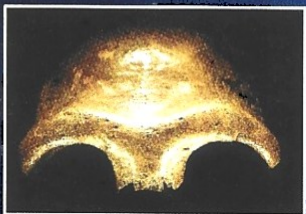
STORIES



Herald of the Age of Clones



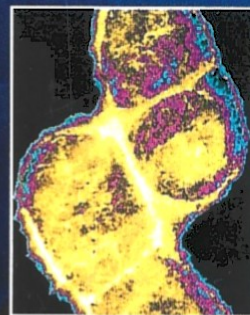
El Niño Takes Aim at a Record



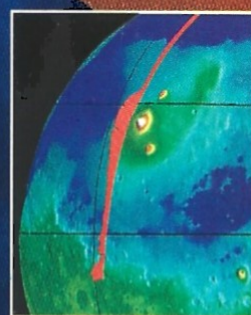
Neanderthal Gives Up His DNA



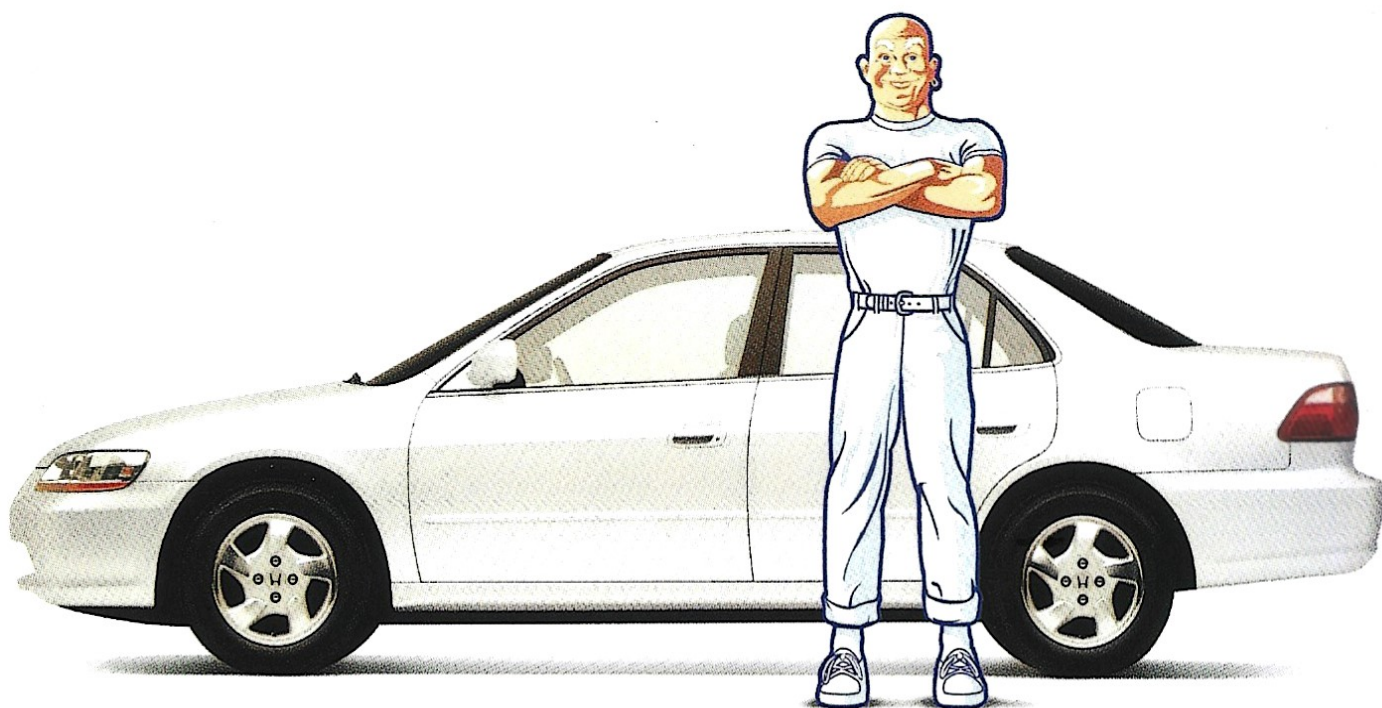
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A Deadly Attack on Beef



Red, Green, and Blue Mars



The new LEV Accord. Drive one, and
see what the neighbors call you.

You are what you drive. Or so the saying goes. Which brings us to the new LEV Accord from Honda. LEV is short for Low-Emission Vehicle. Which means it's clean. How clean?

Our engineers tell us it meets a seventy percent lower emission standard for smog-contributing reactive hydrocarbons than the current federal regulations require. But you can tell your neighbors, "Gee, it's really clean."

It accomplishes this feat with no sacrifice in performance. And no increase in cost.

In other words, it's exactly like many other Honda products. From our lawn mowers to our automobiles, we build products here in America that balance your desire for fun and performance with society's need for cleaner air. And better fuel efficiency.

Which means the folks who live in your neighborhood will come to the only logical conclusion. That you've made a responsible, thoughtful, just plain smart decision to drive the new low-emission LEV Accord.

Who knows, maybe you'll even acquire a new nickname in the process.

HONDA
Thinking.

Stable-Eyes

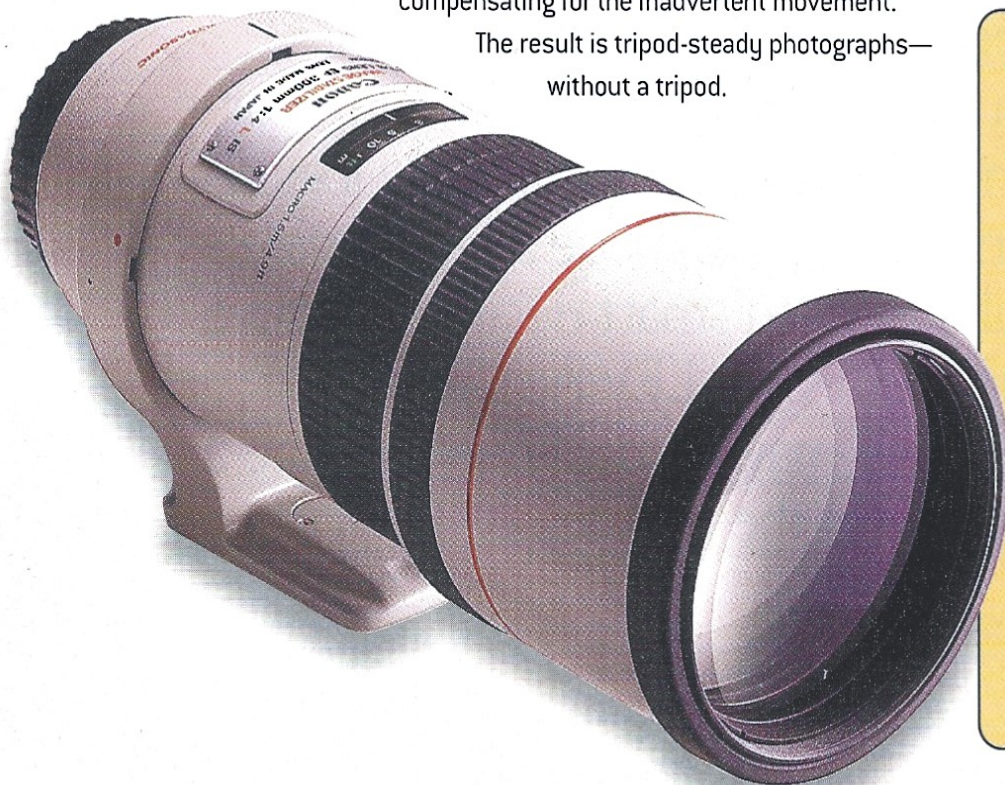
The world is unpredictable. Especially when you're trying to photograph it or take a closer look through a pair of high-magnification binoculars. Jiggle your hands just a little and ordinary optics pay you back with a blurred image. IMAGE STABILIZER technology from Canon can eliminate the little bumps life throws your way.

Retire your tripod

Telephoto and zoom lenses are unmatched for getting you close to your subject. Yet without a cumbersome tripod, their high magnification makes them vulnerable to camera shake, especially when shooting in low light or at a slower shutter speed. But not the EF 300mm f/4L IS USM and EF 75-300mm f/4-5.6 IS USM lenses from Canon. With these groundbreaking Image Stabilizer lenses for SLR cameras—the only SLR lenses that offer Image Stabilizer technology—Canon engineers have all but eliminated the problem.

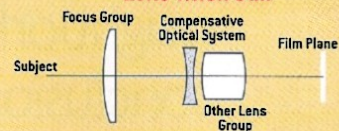
This innovative system controlled by a built-in 16-bit microcomputer automatically counters unwanted camera motion. Gyro sensors detect even the slightest shake. They measure its magnitude and direction and signal the microcomputer. This information is relayed to an electromagnetic coil which shifts the appropriate lens group, instantly repositioning the image and compensating for the inadvertent movement.

The result is tripod-steady photographs—without a tripod.

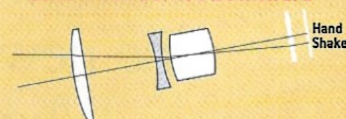


Compensative Optical System For Canon EF Lenses

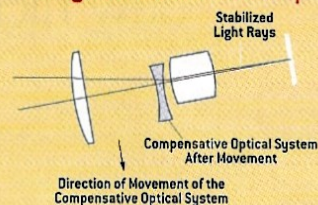
Lens When Still



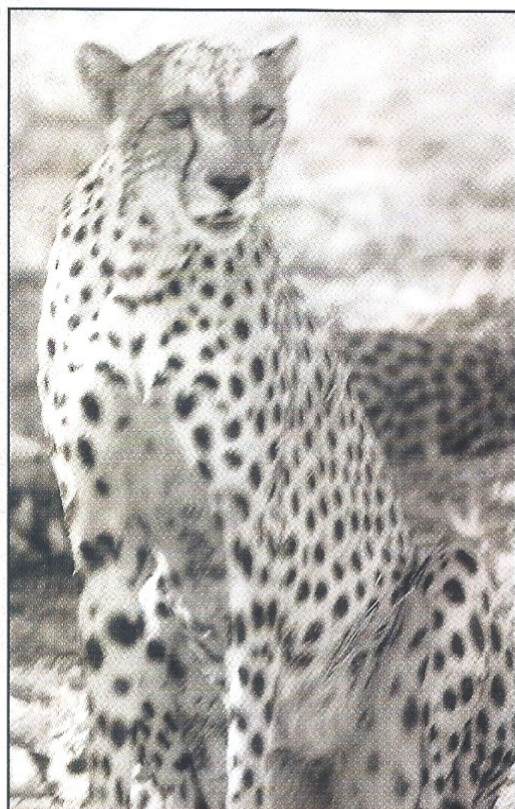
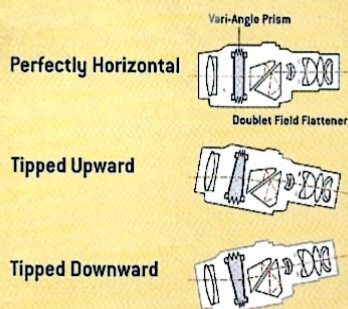
Lens When Jerked Downward



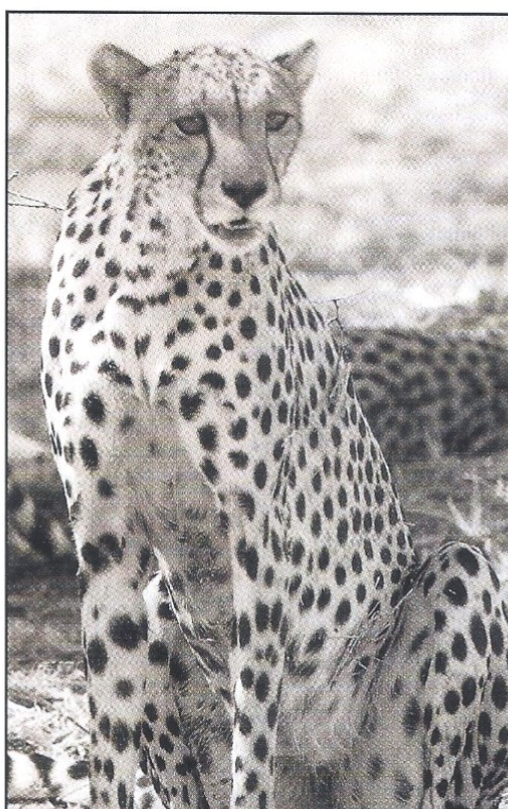
Counteraction By Image Stabilizer Lens Group



Vari-Angle Prism System For Canon Binoculars



WITHOUT IMAGE STABILIZATION



WITH IMAGE STABILIZATION

A clear difference

In the world of high-power binoculars, hand-held viewing has always been a shaky proposition. At least until Canon introduced their binoculars incorporating Image Stabilizer technology—with the same stabilizing benefit found in their acclaimed Image Stabilizer SLR camera lenses.

Canon originally introduced the 12x36 IS and the 15x45 IS binoculars, and they are breaking new ground again by making Image Stabilizer technology highly affordable. The new 10x30 IS binoculars offer all the advantages found in their

predecessors, at a lower price. Light and compact, the 10x30 IS features Canon's innovative Super Spectra multicoating for a bright, sharp image with perfect color balance. Canon's revolutionary active Image Stabilizer system keeps everything steady.

At the heart of the system is a unique actuator-controlled Vari-Angle prism. Independent sensors linked to a dedicated control circuit detect movement or vibrations and relay a corrective signal to the prism drive actuators. The actuators then instantly and continuously adjust the prism shape, maintaining a steady image. Fine detail is resolved and eye strain and fatigue disappear. What could be clearer?

For more information on the complete line of innovative products from Canon, call **1-800-OK-CANON**, or visit the Canon web site at <http://www.usa.canon.com>

Canon



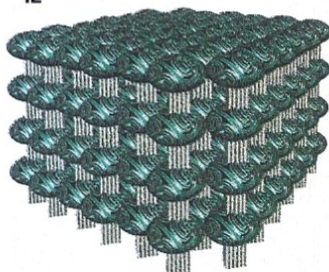
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THE WORLD OF SCIENCE



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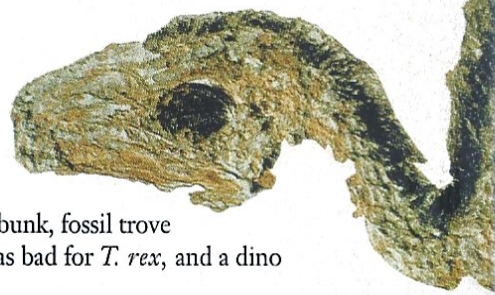
The genes of 1997, how to make a chromosome, disaffected mice, and why men don't get it (because they pass it on).

42 Chemistry

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46 Evolution

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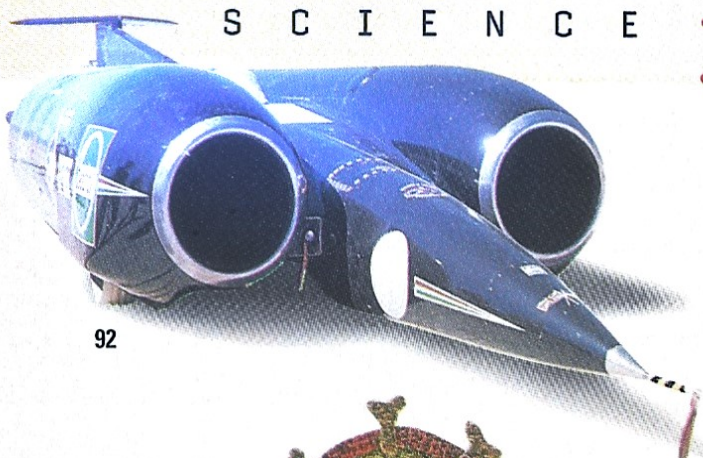


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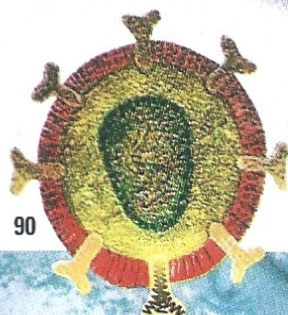
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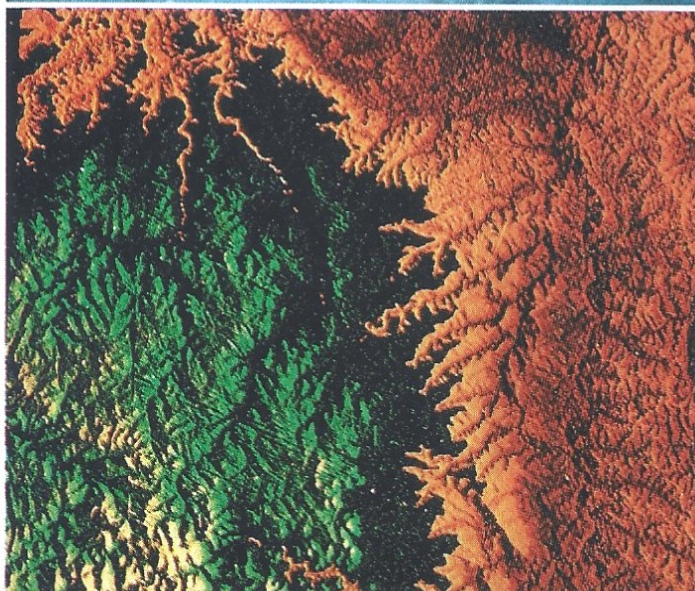


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70 Plants

Elms strike back, an old bisexual, and tobacco takes aspirin.

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80 Earth

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Plankter bites fish, screwing up testosterone, the clean air that isn't, a paucity of potties, what it's all worth, and those bomb tests were bad for us.

COVER: Mushroom cloud (background): © Omikron/Photo Researchers; Mars: courtesy USGS; Dolly: © Remi Benali and Stephen Ferry/Gamma Liaison; El Niño: courtesy JPL; Neanderthal browridge: John Reader/SPL/Photo Researchers; *E. coli* micrograph: © Alfred Pasieka/Peter Arnold; Mars: courtesy USGS



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Over Rover

BY MARC ZABLUDOFF

SOMETIMES A YEAR ROLLS OVER US SO HARD AND SO fast that we can grasp only its portent and not its meaning. The past year in science, at least, has left many of us feeling that way, now that we cast an editorial glance backward. It's not just that science quickened its pace in 1997—though the announcements from all comers, genetics labs to astronomical observatories, did in fact follow one another at astonishing speed. It's more that several key events transcended science's parochial boundaries and dominated the general media for days and weeks on end. And they ensured that datelines for the year's top stories would include some very, very remote locales.

In July a cleverly slimmed down mission to Mars brought that long-promised world achingly close. Sky watchers and Web watchers and TV watchers were delighted as an endearingly small Erector-style rover nuzzled up to some big, cold red rocks. Though critics mildly noted that the Pathfinder mission was more a triumph of publicity management than science—even the rocks, bearing names like "Yogi," seemed to have been scripted—no one could deny the stunning success of the engineering nor the power of the Martian images to engage a new generation of explorers (and taxpayers).

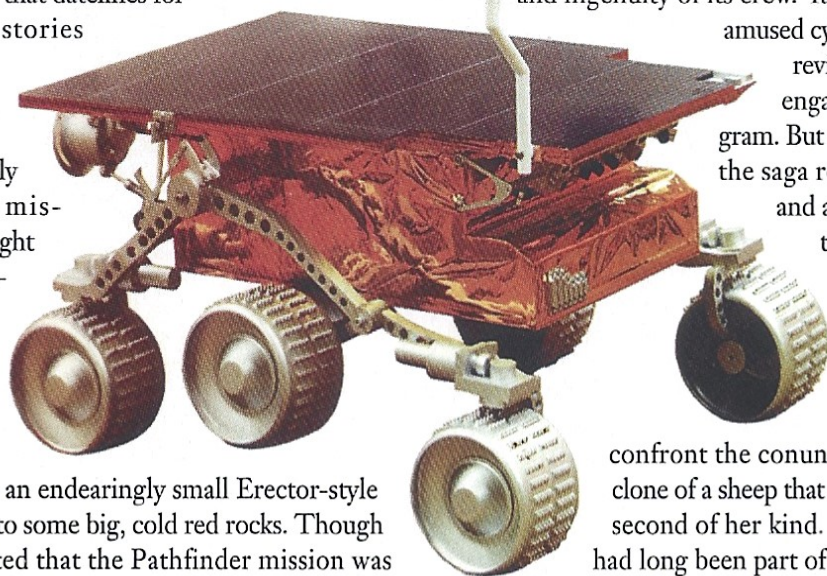
Meanwhile, down the cosmic road a tad (a tad in this case being 500 million miles or so), another clever probe named *Galileo* was spinning its intricately laid course among the

Jovian moons: Io, Ganymede, Callisto, and Europa. Most beautiful among them, at least to those longing for more than alien geology, was Europa. Beneath its icy surface, it appears, is an ocean—an unfrozen, liquid ocean. And within that ocean, a number of researchers say, dwells the faint possibility of life, in barely imagined, if primitive, form.

A more sophisticated life-form in space also demanded attention this year, aboard the Russian station *Mir*. No one could have missed the many news reports detailing the mishaps that crippled the space station and taxed the patience and ingenuity of its crew. Tales of accident and ineptitude amused cynics, infuriated supporters, and revived demands for American disengagement from the Russian program. But to more-sympathetic witnesses, the saga revived memories of *Apollo 13* and again pointed up the fragile nature of human enterprise away from Earth.

Even here on the home planet, though, our ground seemed less than solid. Last February we were forced to confront the conundrum of Dolly, a Finn Dorset clone of a sheep that was simultaneously the first and second of her kind. *Cloning*, of course, as a word, had long been part of the vernacular, but as a practical immediate prospect, cloning came as a shock, a sudden bright crystalline image of a future that many of us are not ready for.

Ready or not, though, here we go. In a couple of years, when the millennium turns, we'll all likely be overindulging in retrospection. We'll be taking stock of our culture and our world and asking, How on Earth did we get *here*? Odds are we'll be looking back to 1997 for an answer.



If you think it's hard getting to

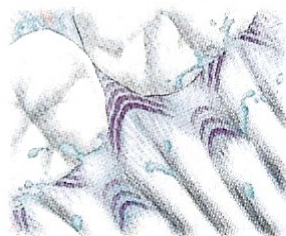
MARS

try getting to plaque three millimeters

BELOW THE

GUMLINE.

With all due respect to the Pathfinder program, exploring the farthest reaches of *inner space* can be almost as challenging. That is, unless you have the



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brush.¹ So like the Mars Sojourner, we too like to seek out life forms in hard-to-reach places. Only we blow them away.

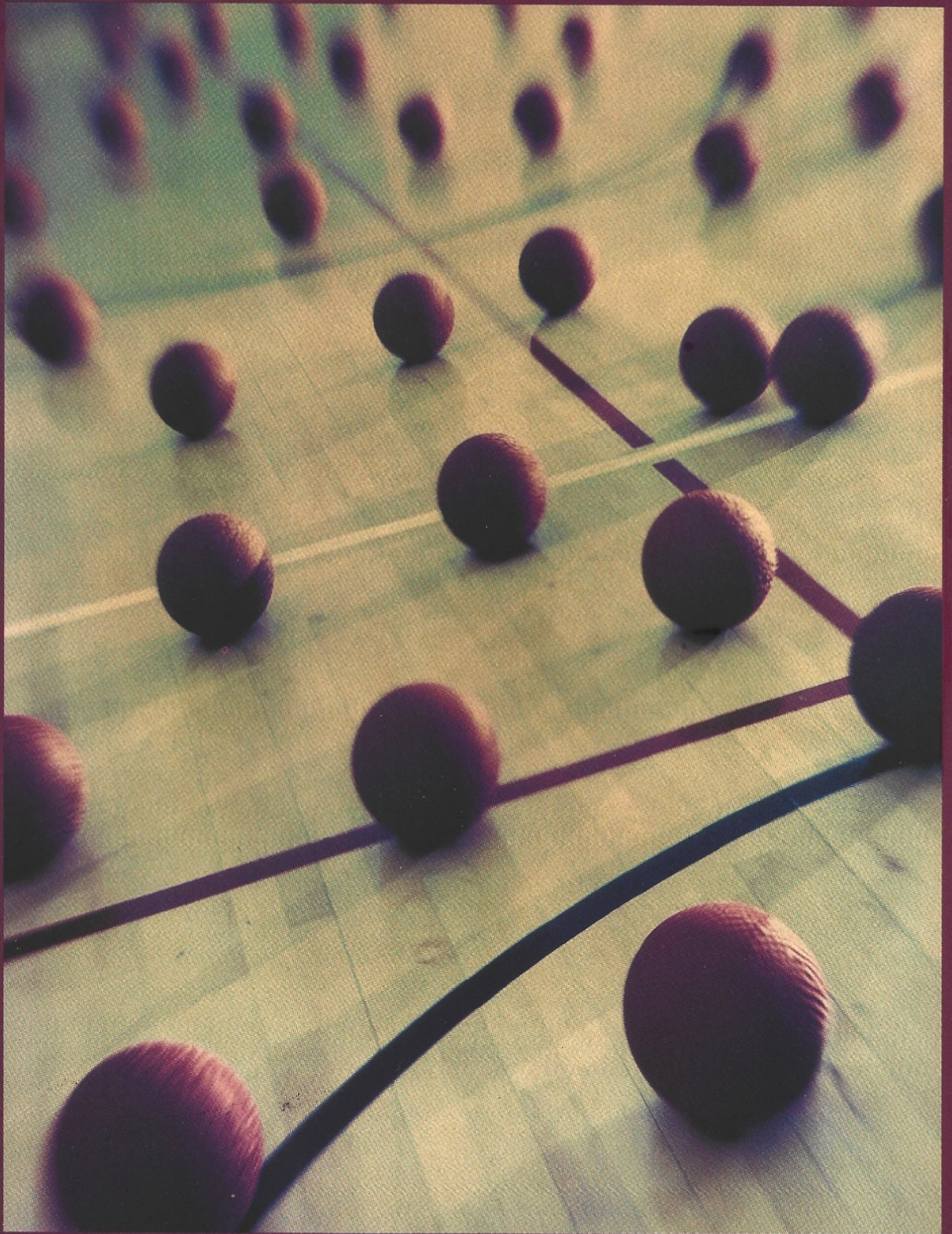


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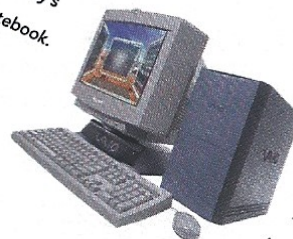
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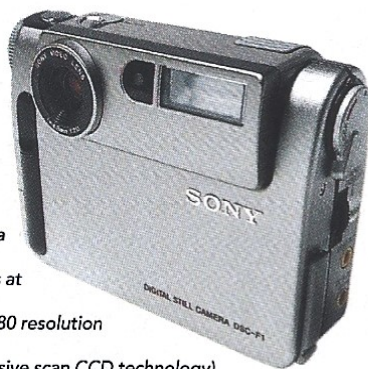
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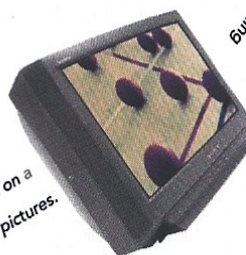
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SONY

TIM APPENZELLER

("Wee Comets Again," page 81) is the features editor of *Science*.

BOB BERMAN

(*Night Watchman*, page 106) is director of Storm King Observatory in Cornwall and Overlook Observatory near Woodstock, New York. He also produces *Skywindow*, a show heard weekly on public radio.

KATHRYN BROWN

("Not a Pretty Picture," page 104; "Iodine Wind," page 105), a freelance writer in Columbia, Missouri, often writes about environmental and biomedical topics.

CATHERINE DOLD

("Tobacco Row," page 58; "The Jaws You Can't See," page 102; "Uncleared Air," page 103) is a freelance writer who has "escaped New York" for Boulder, Colorado. Dold wrote about the battle over corn ancestry in *DISCOVER* in December.

SAM FLAMSTEED

("It Turns Out They're Truly Titanic," page 30; "Saturn, 2004," page 76) has written pseudonymously for *DISCOVER* since 1988.

DAVID H. FREEDMAN

("A Somewhat Biggish Star," page 27) is a contributing editor of *DISCOVER*. He is the author of *Brainmakers* and coauthor of *At Large: The Strange Case of the World's Largest Internet Invasion*.

PATRICIA GADSBY

("Where's the Beef?" page 57; "Perchance to Die," page 64) is a contributing editor of *DISCOVER*. She is currently working on a book about food and eating.

ANN GIBBONS

("Ancient History," page 47; "Cretaceous Pompeii," page 48; "Theropod in Progress," page 50) lives in Pittsburgh, where she teaches science writing at Carnegie Mellon. Her own writing is chiefly about evolution and ranges from dinosaur paleontology to human origins.

JEFF GOLDBERG

("Backward Blood," page 63) is the author of *Anatomy of a Scientific Discovery*.

RICHARD A. KERR

("Cheaper, Faster, Bouncier," page 72) is a senior writer at *Science*, where he covers earth and planetary sciences.

UNMESH KHER

("A Man-Made Chromosome," page 40; "Loner Mice," page 40; "Roaches Cause Asthma," page 58; "His Chickens Quail," page 66) is a former *DISCOVER* intern.

BRUCE L. MILLER

(*Vital Signs*, page 16) is a behavioral neurologist at UCLA School of Medicine and director of medical affairs for the John Douglas French Foundation for Alzheimer's Disease. In addition, Miller says, he has "a specialized interest in the neurological basis for creativity and art."

ROBERT POOL

("Simple as Sand," page 52; "Score One (More) for the Spooks," page 53; "Look, Ma," page 93; "Being There (and Everywhere)," page 96) is a freelance writer in Arlington, Virginia.

TERRY H. STICKELS

(*Brain Beggars*, page 108), former games editor for *MENSA's Constellation* magazine, has been creating puzzles since age 11. He is the author of *Mindstretching Puzzles*, as well as a daily calendar and two decks of cards called *Mind-bending Puzzles*.

MARK WHEELER

("Them," page 88) is a contributing editor of *DISCOVER* in southern California whose home remains free of ant infestation.

CHRISTOPHER WILLS

("A Sheep in Sheep's Clothing?" page 22) is a professor of biology at the University of California at San Diego and the author of several books, including *The Wisdom of Genes* and *Yellow Fever Black Goddess: The Co-evolution of People and Plagues*, which was recently published in paperback.

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A Passion for Painting



Suddenly, at 52, Mr. Carter changed. Now he cared only for art and scorned the world he had known.

BY BRUCE L. MILLER

AT THE TIME OF HIS WIFE'S DEATH, John Carter was a shy and conservative 52-year-old man whose most distinguishing traits were an uncanny ability to remember numbers, a two-stroke golf handicap, and a profound devotion to his wife. So the prolonged grieving that followed her death surprised no one. But when John decided to leave his brokerage firm and become an artist, his family and friends were shocked. To their knowledge, John had never before shown any interest in art whatsoever; indeed, he might have been the only man in his Connecticut suburb who had never visited an art museum.

To his college-age twin daughters, John explained that he was feeling bombarded by colors and sounds. His life, he said, had to change. He moved to a simple loft and started dating art students, many younger than his daughters. He gave up eating meat. He began wearing loud purple shirts and yellow pants, attire that seemed silly to those who knew the former John. He began to fill canvases with streaks of purple, yellow, red, and green. They impressed no one. Still, no one doubted that John was in great mourning, and if the price of being an artist was living with an extreme intensity of feeling, then he was paying that price.

John began to tell friends of his new ability to see not only colors but sounds. Sometimes, he explained, he felt *open*; during these periods, colors bounced through

his head like notes of music, and each shade of the rainbow vibrated with a clarity that could bring him to tears. On these open days, John was warm and mellow, spending many hours painting in solitude, leisurely capturing on canvas the beautiful hues and images of flowers and animals that raced through his mind. When he felt *closed*, though, he was sad and irritable, grimacing at the bark of a dog or an intrusive shaft of sunlight.

No one can remember exactly when John's paintings began to appeal to the eye, but it seemed to happen around the same time that he began to have trouble remembering the meaning of words. At first people assumed that John was kidding when they would say a common word like *key*, and John would repeat back, "Key, key, what's a key?" With time, John comprehended fewer and fewer words, and the words he chose to convey his own thoughts became more and more simple. John had been an articulate man. But within three years there was little trace of his formerly rich speech. He conversed in short, simple

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phrases, like "I feel open" or "I feel closed."

As his speech became more impoverished, John grew more flagrant in scorning social rules. One day the police called his daughters to bail their father out of jail after he had appeared nude in a public swimming pool. Other days, John walked the streets of the city, intentionally bumping into and berating strangers. His temper grew so vicious that he began kicking his dog. His daughters began finding pens that John had swiped, and they noticed his tendency to steal tips off restaurant tables. Soon John required caretakers around him 24 hours a day to prepare his meals, wash his clothes, calm his moods, and keep him out of jail. His compulsions grew stronger. He often dragged his caretakers past banks, phone booths, Laundromats, and restaurant tables, hunting for dropped coins.

Unexpectedly, as John's social skills and language abilities eroded, his visual senses became more acute. He found coins that no one else would have found, and he became exquisitely sensitive to sudden changes, such as subtle shifts in the weather. John devoted these new visual skills to his painting.

Over the years the complexity of John's art increased. His early paintings had featured simple colored lines; now

shell of what he had been. His daughters sought medical opinions about his condition; diagnoses ranged from Alzheimer's disease to depression to schizophrenia. No medication helped.

John's language skills continued to falter and his violent outbursts grew more frequent. His paintings became less realistic. One series featured elephants, pigs, and dogs with rounded, slipperlike feet and distorted facial features. Next came his doll paintings. The images were bizarre and faintly sexual—one image featured a doll emerging from another's abdomen. The only element they shared with his lovely bird paintings was the lavish use of purple and yellow. John's open times were now rare, and he was frequently plagued by closed periods during which he could not paint. Sounds and colors had been a source of joy; now they brought him only pain.

It was about eight years after he began his artistic life that I first met John. I am a neurologist who specializes in behavioral disorders, and John's daughters brought him to me in the hope that I might shed some light on his condition. When John arrived for his appointment, he was dressed in a long-sleeved purple T-shirt and yellow pants. He was tall and

ness of an athlete. He showed no deficits on the basic neurological exam, which tested his senses, motor skills, and responsiveness. I then performed a detailed assessment of John's language, intelligence, memory, decision-making abilities, and visual and spatial skills. John's language consisted of a series of pat phrases, and he kept repeating, "Doctor, can you help me? Last week, every day I was closed to color and sound." He could not name simple objects like a watch or pencil and failed almost all memory tests. Yet he was able to re-create from memory more intricate designs than any other patient I had ever examined, and he copied complex designs with extraordinary precision. He excelled on these two visual tasks but failed the others.

We then performed imaging studies of John's brain. The human brain is divided into two hemispheres; each hemisphere houses four different lobes, or regions. The frontal lobes, of course, lie in front, and the occipital lobes lie in back; sandwiched in between are the parietal lobes, on top, and the temporal lobes, below. The images of John's brain revealed diminished function in the front of his temporal lobes—a region that is involved in many social and perceptual tasks. Yet the rear portions of John's temporal lobes—and his parietal lobes—were normal.

That helped explain John's unusual condition. The rear part of the temporal lobe is involved in our ability to visualize images; the rear part of the parietal lobe is involved in our ability to put those visual images on paper. Both skills are usually lost in Alzheimer's patients. In John, however, these areas were either normal or improved in function.

These images confirmed what John's progressive deterioration already suggested. John suffered from frontotemporal dementia, a degenerative disorder that causes loss of brain cells both in the frontal lobes and in the front part of the temporal lobes. The disorder is sometimes inherited via a defective gene from one parent, and patients are usually spared signs of the disorder until they reach their fifties. Because the brain-cell loss occurs in parts of the brain that help regulate social behavior, personality changes are the most common manifestations of the illness. Patients tend to become either uninhibited or apathetic.

Until recently, most of these individ-

John repeated softly, "Doctor, can you help me? I feel closed to colors and sounds." Then he abruptly lay down on the floor.

he was exploring interesting rounded shapes. For several years, he painted richly colored flowers, boldly laid over a stark monochromatic background. At age 58, some five years into his illness, John spent three weeks in Hawaii, where he felt open almost every day. After returning home, he re-created from memory the beautiful birds of Hawaii, usually in purple and yellow. These tropical birds—perhaps his most attractive pieces—evoked the feeling of another world. Several won prizes at local art shows. Yet this accomplishment seemed to give him little pleasure, and by the time he received the awards, John was a

oddly handsome, but his drawn face made him appear all of his 61 years.

During his visit, John never smiled or showed any reassuring or responsive facial expressions. His voice was soft and flat, and he was so remote and distant that it was hard to empathize with him. John repeatedly stated in a monotone, "Doctor, can you help me? I feel closed. I'm closed to colors and sounds." At one point, he said quietly that he was tired and abruptly lay down on the floor. He did not rise for several minutes.

After he stood up, I began his examination. John's coordination was excellent, and he moved with the agility and light-

uals were thought to suffer from a primary psychiatric illness—such as schizophrenia or bipolar disorder—while still others were misdiagnosed as having a degenerative condition that often accompanies aging, such as Alzheimer's. Unfortunately, like so many degenerative diseases, there is no cure for frontotemporal dementia. When I explained the disease to John and his daughters, I told them why I thought his intense interest in visual images was probably directly related to his condition.

Most patients with frontotemporal dementia do not become more artistic as their disease progresses. John was an exception. Some of the explanation for his artistic flowering will remain hidden forever, but it was probably fueled by a mix of talents, experiences, and brain circuitry unique to John. Yet an anatomic anomaly in his brain imagery held a very strong clue. Unlike those of most patients with this disorder, John's frontal lobes, the regions that govern our ability to exercise complex thought, judgment, and planning, were spared. His loss of brain cells was restricted to the front part of the temporal lobes. This unusual pattern of brain-cell loss probably contributed to John's curious combination of cognitive impairment, language deficit, bizarre behavior, lack of inhibition, and artistic creativity.

The brain contains a series of excitatory and inhibitory circuits; when one circuit is stimulated, other areas are turned off. This reciprocal inhibition prevents us from activating competing brain circuits simultaneously. Imagine trying to type a paper, remember a list of words, and compose a poem at the same time. Clearly, when we try to do so, the efficiency of each competing brain circuit decreases. This concept of reciprocal inhibition may help explain John's sudden burst of creativity.

The front part of the temporal lobes houses our social brain. When the social brain functions well, we succeed with those around us, but when it is dysfunctional, socially unacceptable and bizarre behavior emerges. In contrast, the rear part of the temporal lobes—the posterior temporal lobes—helps us interpret and make sense of the world's visual attributes. Localized here are specialized cells that respond to shape, color, movement, and faces. When an artist imagines the

visual images that he or she puts into a picture, the posterior temporal lobes become active. And skills housed in the adjacent parietal lobes help the artist place that image on paper.

In John's case, dysfunction in the front of his temporal lobes led to progressive deterioration of his well-developed social inhibitions and restraints. At the same time, it heightened activity in his posterior temporal lobes, leading to a continuous flood of visual imagery that preoccupied, and often tormented, his waking moments. In other words, the inhibitory fibers that ordinarily turn off stimulation from the *visual* brain seemed to have stopped working, perhaps allowing the artist in John to wake from dormancy.

That, at least, is what I believe is happening. What I do not understand is why John's condition prompts him to alternate between feeling open and shut down. I can only speculate that his mood swings are probably akin to the highs and lows that patients with bipolar disorder experience. These swings may be caused by an inability of the inhibitory and excitatory circuits to reach equilibrium. It may be like a ther-

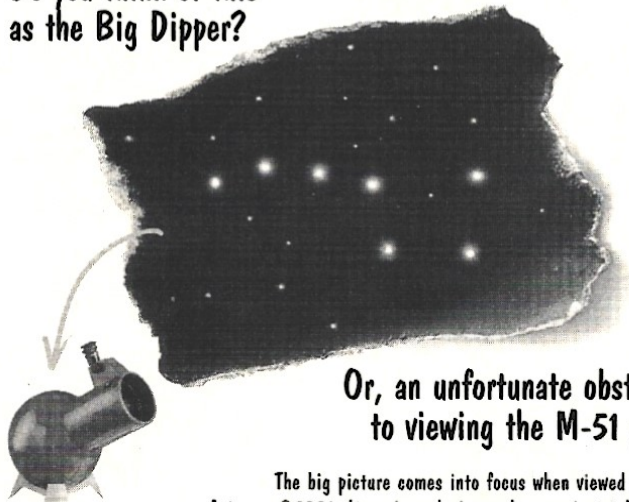
mostat that has lost the ability to regulate itself.

I continue to see John regularly. Occasionally, I prescribe antidepressants to help lift him out of the gloom that descends on him. At this stage in his disease, he is living at home with a caretaker. He is speaking less and less, and he no longer has any interest in painting.

John's long obsession with visual images is not common among patients with his disorder. Still, he is not the only patient in whom we have seen artistic ability bloom among the ruins of progressive cognitive and social impairment. Joan, a middle-aged housewife, began drawing beautiful scenes she remembered from her childhood. Mark, a businessman, made intricate wax figures and compulsively photographed buildings from many angles. Miguel, a janitor, painted pictures from what he remembered of Native Americans in New Mexico. All three patients were ultimately diagnosed with frontotemporal dementia. Paradoxically, in all of them, a period of exceptional creativity heralded the beginnings of a tragic disease. □

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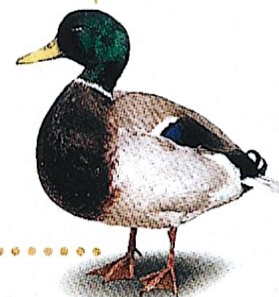
July 15, 1986:
Chrysler Corporation designers sketch an idea that moves the passenger cab forward on the chassis and the wheels to the corners, creating a larger space for people. It contradicts eight decades of automotive design.



January 8, 1997:
Auto Show crowds get the first glance at the next generation of cab-forward thinking in the all-new 1998 Dodge Intrepid and Chrysler Concorde. Competitors' shoulders sag.



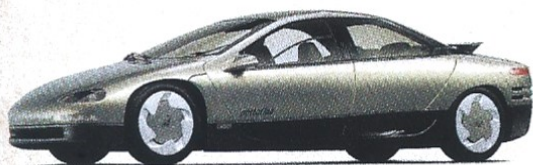
December 31, 1996:
20 major awards for cab-forward sedans. So far.



March 23, 1994:
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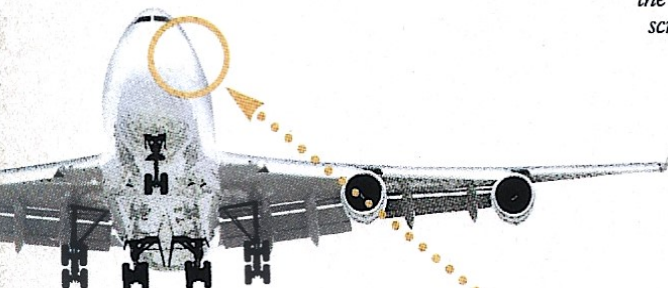
September 9, 1987:
Their creation, dubbed Portofino, debuts at the Frankfurt Auto Show. Acclaim leads a Chrysler Corporation exec to ask: "Why can't we build a production car like this?"



January 7, 1989:
Chrysler's design and engineering teams agree their new midsize car should reflect the thinking in Portofino—scrapping current plans.



September 8, 1991:
International Motor Press Association gets preview of new "cab-forward" sedans at Moran's Restaurant in New York. Journalists are, briefly, too excited to eat.



April 2, 1993:
Quote from the *Los Angeles Times*: "Thanks to that cab-forward design, rear seating in [the Chrysler LHS] offers the same knee and leg room as first class on Air France."



September 15, 1992:
Chrysler Concorde, Dodge Intrepid, and Eagle Vision sedans are launched. Their cab-forward profile "makes everything else look old," according to one writer.



March 12, 1993:
Two Chrysler designers, working on new compact sedan late on Friday, decide to go for Chinese food. Nine hours later they arrive in Chinatown—in New York.



November 6, 1992:
To get mall shoppers to stop and test their seating prototype, a group of Neon engineers offers free hot dogs.

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A Sheep in Sheep's Clothing?

NEARLY ANYTHING GOES these days in animal breeding, and in that context what Ian Wilmut of Edinburgh's Roslin Institute accomplished was just the logical next step. Wilmut took the cell nucleus from a Finn Dorset sheep, substituted it for the nucleus of an egg from a Poll Dorset, and implanted it in a ewe of yet a third breed, a Scottish Blackface. The surrogate mother then took over, using maternal magic that has yet to be duplicated in the laboratory, and five months later a lamb called Dolly met the world. Last February, the world met Dolly in an explosion of photographic flashes. Of all the thousands of pictures that came out of Scotland that month, one of the more remarkable was the one that showed Dolly the almost-Finn Dorset standing next to her strikingly different surrogate mother. That, after all, had been the point of using the three different breeds: so that it would be readily apparent that Dolly had not gotten her genes from either the egg donor or the surrogate mother—that she really was the first clone of an adult mammal.

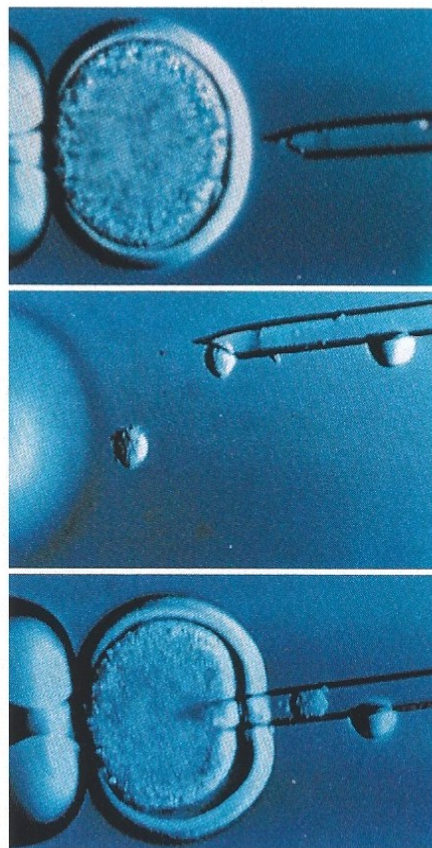
Adult frogs had been cloned before, and so had embryonic mammals. Wilmut himself had cloned embryonic sheep a year earlier, fusing a sheep fetal cell with an enucleated egg cell, one that had its nucleus removed, and then implanting that new egg in a ewe. But it was Dolly who catapulted him onto the world stage. Not only did her genes come from an adult, six-year-old sheep but they came from a dead one—from frozen mammary tissue.

Many scientists were astonished by that technical achievement. It had been assumed that adult cells lost their "totipotency," the ability to give rise to a viable, fertile organism. Adult cells are already specialized, and that process had been thought to involve irreversible changes in their genes. For instance, the DNA may

get repacked in such a way that some genes are not available for making proteins. Dolly proved, though, that at least some mammary cells in sheep retain their youthful plasticity—they just need to have it restored somehow.

That's where Wilmut's team made its breakthrough. Previous attempts at cloning from adult cells had failed, they decided, because the cells used were too metabolically active, or in the wrong stage of the cell cycle, or had the wrong set of genes turned on. The Scottish researchers compensated for these possibilities by starving the cells for several days before fusing them with enucleated

To clone a sheep: Suck nucleus from egg. Grab adult cell. Insert into egg. Wait and hope.



eggs. In this state of deprivation, the cells' DNA-copying machinery ground to a halt, arresting the cell cycle and forcing the cells into a metabolic torpor that presumably matched the quiescence of an unfertilized egg. Even with this technical sleight of hand, however, Dolly was Wilmut's only success in 277 tries.

ABS Global, a Wisconsin company, has since claimed to have improved on the Scottish procedure with a technique that can rejuvenate more than just mammary cells: it says it has created cow embryos from skin, bladder, and udder cells of an adult cow. The cells were fused with enucleated eggs, as at Roslin. But once the fused cells had begun to divide, a single cell was extracted and inserted into another enucleated egg. Once that embryo began to form, it was implanted in a surrogate mother cow. In late October, ABS reported that the pregnancies—all with normal-appearing embryos—were well under way. Apparently the passage through the first embryo had helped the adult nucleus revert to its totipotent state.

Dolly, too, looks fine now. But she began life with a nucleus from an adult cell—and cells age. Their chromosomes shorten at the tips. Has Dolly already begun to suffer such damage, and will she suddenly begin aging prematurely? Alternatively, was her originating nucleus undamaged? Or—and this would be the most exciting of all—can the milieu of the egg cell somehow reverse genetic damage due to aging? Is the egg a cellular time machine?

Those were some of the scientific questions raised by Dolly's birth, but it was the ethical ones that preoccupied the public. Even before Dolly, the British Parliament had banned human cloning. In June, President Clinton proposed a similar ban. "Banning human cloning reflects our humanity," he said. "It is the right thing to do . . . At its worst [this new method] could lead to misguided and malevolent attempts to select certain traits, even to create certain kinds of children—to make our children objects rather than cherished individuals."

Biotechnology companies, and the biomedical community in general, reacted negatively to the proposed ban, even though Clinton emphasized that the cloning of animals would still be allowed. Some would argue that cloning is no way to treat animals, either—that they, too, should not be considered mere objects. But if you accept factory-farming them



Dolly

for food and breeding them for medical experiment, as most of us do at least tacitly, then it becomes hard to cavil at cloning. It is just the logical next step.

And it is one that carries enormous promise. Cloning adult animals means quality control. Once you produce an animal with the traits desired, carbon copies will be easy to make. Imagine entire herds of champion milk producers or paddocks full of Triple Crown winners. More plausibly, imagine flocks of sheep or herds of cows producing milk that carries a critical human protein. That is the goal of Wilmut's research, which is financed in part by PPL Therapeutics, a Scottish pharmaceutical company. In July, Wilmut's group announced that it had produced sheep cloned from fetal cells carrying a human gene—and that gene was turned on only in the sheep's mammary glands. Scottish pastures may soon become pharmaceutical factories.

But of course everybody is agog about the possibility of human cloning. Would it necessarily be wrong? One can easily imagine a scenario in which cloning might be a blessing. Suppose a couple has one treasured child and they are unable to have more. Then the child is suddenly killed in an accident. Should the couple be allowed to clone the child and start over? Many of us would say yes.

Moreover, practices that our society already accepts as ethical make it harder

to stake out a morally consistent ban on cloning. If a woman already has the right to conceive a child with anonymous sperm from a sperm bank, in vitro if necessary, with a surrogate mother to bear it if necessary, on what principle do we deny her the right to clone herself? Or a man, if we don't want to be sexist? In humans as in animals, cloning is in some ways just the logical next step. Some would say we've been falling since the top of the stairs, others that we've been climbing to new heights of human liberty—but the point is that once you start on such a path it is hard to stop.

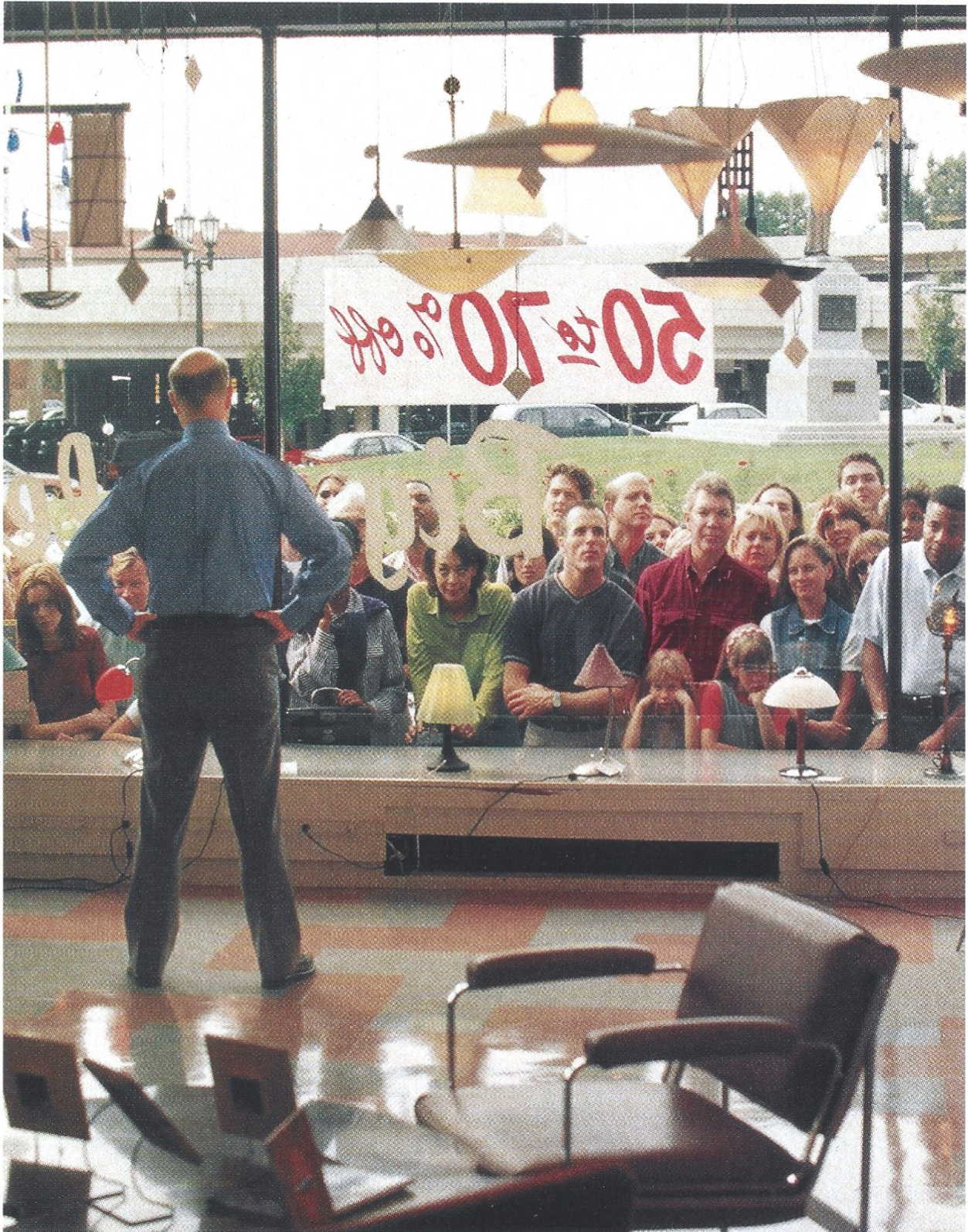
At the moment, technical obstacles to cloning create ethical ones: one reason not to try to clone a human now is that the job would most likely be botched. Wilmut acknowledged this when he testified before a U.S. Senate subcommittee on public health last March. "In previous work with cells from embryos, three out of five lambs died soon after birth and showed developmental abnormalities," he said. "Similar experiments with humans would be totally unacceptable."

Another reason cloned humans seem so unacceptable is the fear that they really would be carbon copies. One response, repeatedly heard this past year, is to point out that genetic clones already exist, namely identical twins. But an even better argument is that identical twins are not really identical—and that clones

would be even less so. The reason is that there are more than genes at work in development, as a July report in *Nature* by genetic epidemiologist Bernie Devlin of the University of Pittsburgh Medical School and his colleagues underscored.

The team examined a long-standing puzzle: Why do fraternal twins who were raised apart from birth tend to be more alike in IQ than ordinary siblings who were also raised apart? After all, fraternal twins and sibling pairs share the same degree of genetic resemblance. Devlin concluded that one strong environmental influence had been ignored: the intrauterine environment which the twins share and the siblings do not. Just as a river cannot be stepped into twice, it appears that a mother's intrauterine environment changes with time.

But a clone and its parent will probably not even develop in the same mother, let alone in the same uterus at the same time and in the same egg. Like identical twins, they will share nuclear DNA, but otherwise they will have far less in common than twins do. Sheep are not the animals in which to investigate all this—they tend to be so alike that even their owners have great difficulty telling them apart. If humans are eventually cloned, though, it seems that we will not find ourselves in a world of ditto-heads. Instead, we will discover just how different clones can be. —Christopher Wills



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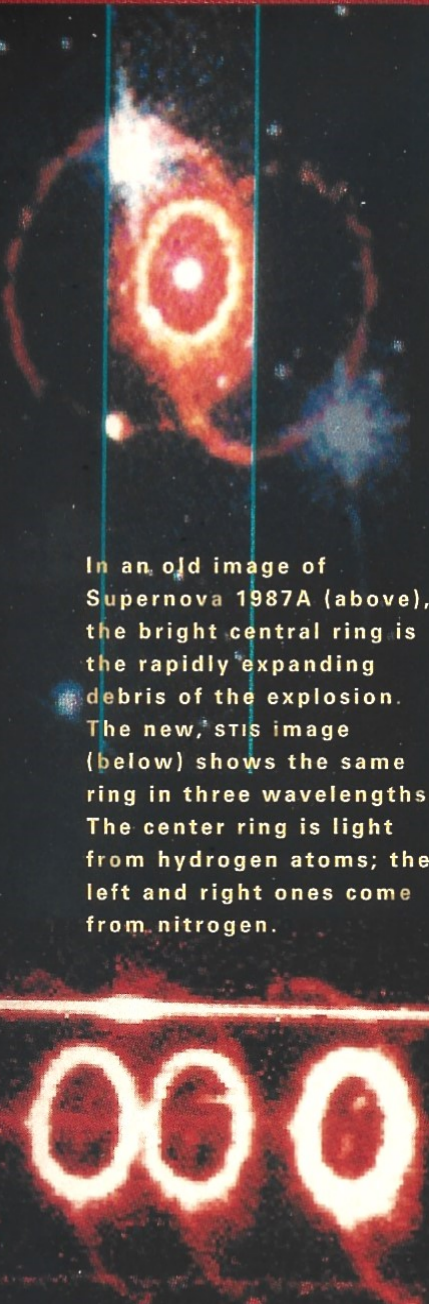
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Hubble's New Prism

LAST FEBRUARY, astronauts from the space shuttle *Discovery* replaced a set of aging instruments on the Hubble Space Telescope with two new instruments designed to look at the colors of the universe in an entirely new way. The first of the two, the Near Infrared Camera and Multi-Object Spectrometer (NICMOS), is a camera that sees shades of infrared light the way normal cameras see colors. The result is an instrument that can see inside dust clouds—dust clouds near the center of the galaxy, for instance, where later in the year NICMOS discovered perhaps the most massive star ever observed (see article opposite).

The other new instrument, the Space Telescope Imaging Spectrograph (STIS),

takes light from an object and separates it into discrete wavelengths—but instead of the colored lines that emerge from an old-fashioned spectrograph, STIS creates a spectrum of images, one at each wavelength. The images seem bizarre at first, but if you know how to look at them, they contain much more information than ordinary spectra or the familiar Hubble pictures, which combine light from just a couple of wavelengths. “You can use this information to work out the chemistry, velocity, and density of the object,” says Bruce Woodgate, the NASA astronomer in charge of the instrument. “And you can do it all at once and get the information you need 40 times faster than with a normal spectrograph.” —Jeffrey Winters



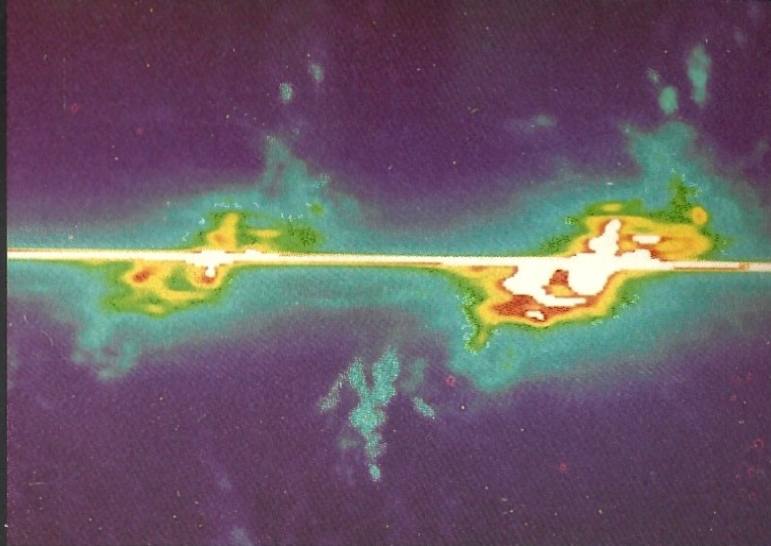
In an old image of Supernova 1987A (above), the bright central ring is the rapidly expanding debris of the explosion. The new, STIS image (below) shows the same ring in three wavelengths. The center ring is light from hydrogen atoms; the left and right ones come from nitrogen.

An old instrument on the Hubble, the Wide Field Planetary Camera 2, made this close-up of the twin hearts of the Antennae—a pair of giant spiral galaxies, 63 million light-years away, that are in the process of colliding. The collision has produced more than a thousand clusters of newly formed stars (the bright blue dots) from compressed clouds of gas and dust (the dark filaments).





Compared with an earlier Hubble image of galaxy NGC 4151 (left), a galaxy that is thought to have a massive black hole at its center, the STIS image (right) shows much more clearly how blobs of gas (seen here at two wavelengths) are jetting out of



the galaxy in opposite directions. Meanwhile, gas closer to the center is plummeting into the black hole. In the older image, that gas is a bright point—but because it is white-hot and radiating at all wavelengths, it is a horizontal line to STIS.

A SOMEWHAT BIGGISH STAR Astronomers have long seen our sun as sort of an average Joe among stars. But lately it seems downright puny, thanks to the unveiling in October of the Pistol Star. Detected near the center of our galaxy by the Hubble Space Telescope's new infrared camera (see story opposite), and named after the gun-shaped nebula that surrounds it, the Pistol is roughly a hundred times as massive as the sun and anywhere from 2.5 million to 15 million times as bright. If it were not veiled by dust, it would be visible to the naked eye, even though it is 25,000 light-years away. If it were placed in the center of our solar system, its surface would extend to Venus. It just may be the brightest, most massive star ever seen.

And this is the lean version of the Pistol. UCLA astronomer Don Figer, who led the team that made the Hubble observations, says the Pistol probably started off with twice as much mass. But it burned half of itself off in a ferocious stellar "wind" and in a couple of extraordinarily violent eruptions a mere 5,000 or so years ago. Those eruptions hurled gas as far as 2 light-years away, creating the smoky nebula. The bigger a star is, the hotter it burns and the faster it runs through its fuel; Figer says the Pistol is only a couple of million years old but is already within a few million years of going supernova—that is, of blowing up. The sun, in contrast, has been around for 5 billion years and has about that long to go.

Although there is a small chance that the Pistol could turn out to be two smaller stars huddled together—Figer's team is taking a sensitive new infrared detector to the Keck telescope in Hawaii next summer to find out—it could also turn out to be even more massive than the initial estimates. Astronomers are surprised that a star so large could ever have been born. Stars are created when clouds of gas gravitationally contract into a ball and ignite at the core from the compression; the conventional wisdom is that a star would ignite and blow off outer layers of gas long before it had a chance to build up

into a Pistol-like monster. "We'll have to come up with new notions of star formation now," says Figer.

Even more intriguing is the possibility that the Pistol is a missing link between ordinary large stars and a handful of exotic, superhot but smaller objects known as Wolf-Rayet stars. Perhaps very large stars become unstable, blow off their outer layers, and end up as brilliant midgets. If so, the debris from the Pistol's eruptions 5,000 years ago may be a snapshot of the first stages of that process.

—David H. Freedman



The Three-Tailed Comet

FOR SKY WATCHERS the event of the year was clearly the arrival of comet Hale-Bopp, which burned bright in northwestern skies from late March through May. The biggest and brightest comet since the Great Comet of 1811, it was visible even through murky city air. The first sightings, in July 1995, had been made by two experienced observers, Alan Hale and Thomas Bopp, and two years later their peers came out in force. Astronomy clubs planned Hale-Bopp parties; amateur photographers flooded the Internet with snapshots and viewing tips. And on another plane entirely, members of a fanatical New Age cult committed mass suicide, hoping to ride the comet to a higher form of existence.

In the ensuing uproar the astronomy seemed almost secondary. But Hale-Bopp was also of great scientific interest: it was the first comet with three tails ever seen.

Even lazy observers could easily spot the bright but squat dust tail, and

a little more effort revealed the narrower tail of ionized gas. The first reports of the third tail came on April 18 from a team of European astronomers at the Isaac Newton Group of Telescopes on the Canary Islands. Their images of the comet revealed a thin, faint, jetlike tail some 30 million miles long and nearly 400,000 miles wide, pointing in a direction almost exactly opposite the sun—and made entirely of sodium atoms. By May, other astronomers had processed their own images of the comet, and they saw a sodium tail too—although not necessarily of the same shape and size. “In our data it is wide—roughly the same size as the dust tail—and it gets wider as it moves away from the comet, and it’s also slightly curved,” says astronomer Jody Wilson of Boston University.

“The European team has suggested that the tail is produced by sodium gas escaping directly from the nucleus,” Wilson goes on. “But that is how you get a narrow tail.” He and his colleagues have another theory to explain the wide sodium tail: the sodium atoms are coming off the grains in the comet’s wide-fanning dust tail. But whereas the dust is pulled by the sun’s gravity into a curving wake behind the comet nucleus, the lighter sodium atoms are influenced more strongly by the pressure of solar radiation and are pushed away from the sun. Thus they separate from the dust and form a distinct third tail—or at least it was distinct if you had a large telescope.

Astronomers don’t expect to find hidden sodium tails in

■ Ions
■ Sodium
■ Dust



A stunning Hale-Bopp (above) wowed observers around the world in spring; astronomers were impressed by the comet’s unprecedented sodium tail (yellow, at right).

all the comets that cross our skies. Last year’s comet Hyakutake, for one, was noticeably lacking in sodium. “You would expect more sodium to come from comets that have more dust,” Wilson says. “That is consistent with Hyakutake. It was almost all ices that turned into gas, and we saw very little sodium.”

—Kathy A. Svitil



Parenthood Incognito.

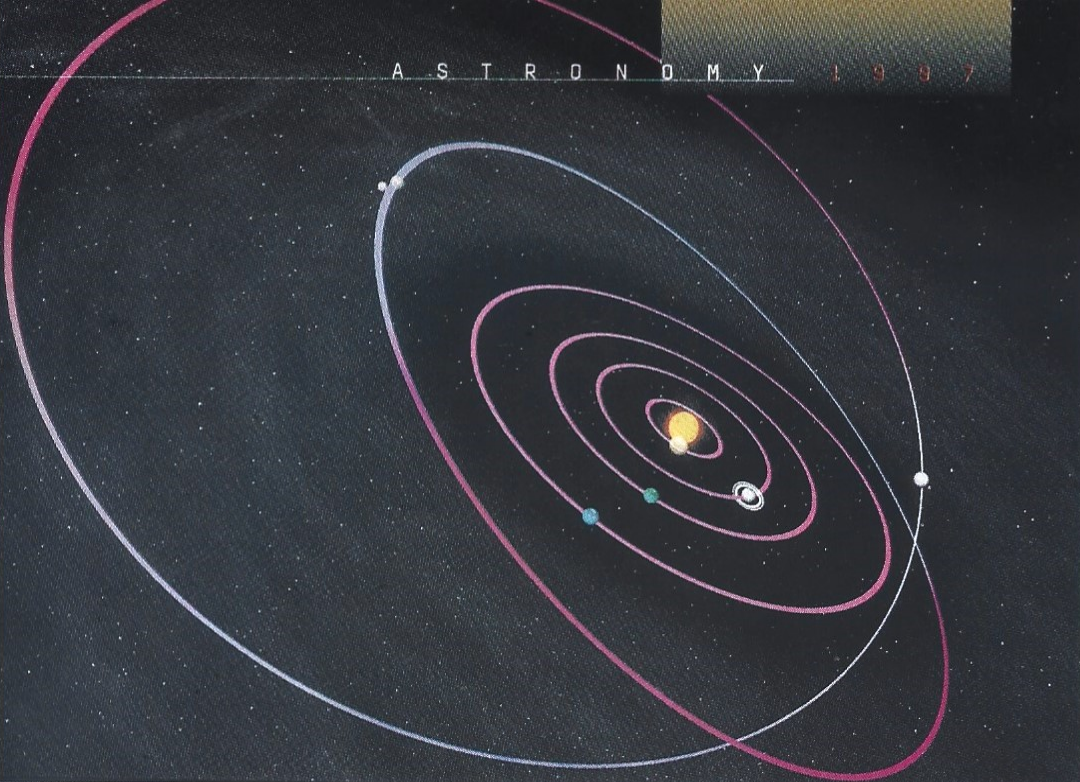


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ECCENTRIC CHARACTER Astronomers Jane Luu of Harvard and David Jewitt of the University of Hawaii in Honolulu have discovered dozens of icy worlds on the edge of the solar system, but none as strange—or as bright—as the one they unveiled last June. In fact, their new find, called 1996TL₆₆, is most likely the first of an entirely new class of objects in the solar system. With an estimated diameter of more than 300 miles, 1996TL₆₆ is neither an ordinary planet nor a moon—its crazy, 780-year orbit being more like that of a comet. From a point near the orbit of Neptune, where Luu and Jewitt found it, it swings out to a distance more than four times that of Neptune from the sun and more than 130 times that of Earth from the sun, all while tilted at an angle of 24 degrees from the plane of the solar system. No one is entirely sure how this “miniplanet” got there, but Luu guesses there are as many as 6,000 others waiting to be discovered. “We didn’t have to cover the entire sky to find this,” she says. “We found it relatively easily, so unless we were incredibly lucky, there should be many others like it.”

—Jeffrey Winters

It Turns Out They're Truly Titanic

TWO YEARS AGO, NASA's Marshall Space Flight Center in Huntsville, Alabama, hosted a conference on the astronomical phenomenon known as gamma-ray bursts. Plenty of observational astronomers showed up, but, says Gerald Fishman, a Marshall astrophysicist, “the theorists mostly stayed away.” It wasn't for lack of interest: since their discovery in the late 1960s, these brief flashes of high-energy electromagnetic radiation have been one of the enduring mysteries of astrophysics. Explaining

them would qualify as a major coup.

The trouble was, nobody could figure out where the gamma-ray bursts were—in and around our Milky Way galaxy or at the far reaches of the universe. That put the theorists in the position of trying to explain something that might be either a distant mountain or a nearby molehill. No wonder they didn't make the trip. “Things were rather muddled,” admits Fishman.

This September, though, when astronomers reconvened in Huntsville for

a follow-up meeting, the theorists came in droves. Thanks to a series of dramatic discoveries, it was suddenly and inescapably clear that gamma-ray bursts almost certainly take place deep in the cosmos, not nearby. And that meant they were not just moderately energetic blasts but rather some of the most powerful explosions in the universe.

For a long time after gamma-ray bursts were discovered—accidentally, by Defense Department satellites looking for Soviet nuclear detonations in space—astronomers knew next to nothing about them. In the mid-1980s, though, a Princeton astronomer named Bohdan Paczyński pointed out that they seemed to be coming from all directions in the sky,

in which case their sources must be evenly distributed, too. The only objects that fit that bill are comets at the edge of the solar system, in the so-called Oort cloud, and galaxies far out in the universe. Comets being way too cold to emit gamma rays, Paczyński advocated the latter hypothesis—that the bursts came from far away, which meant their energy must be preposterously large. “At first,” recalls Fishman, “Bohdan was the only one who took that position.” So few bursts had been observed at the time that their distribution was still debatable.

In 1991, when the Compton Gamma Ray Observatory satellite went up and started recording bursts at the rate of one a day, it became clear that Paczyński had been right about their even distribution. But the clinching evidence for his hypothesis came only this past year, from an Italian-Dutch satellite known as BeppoSAX. Unlike all its predecessors, it has the ability to pinpoint the position of a burst—and on February 28, for the first time, it located one in a patch of sky about one-sixth the diameter of the full moon. Optical telescopes swung into operation and detected a fading spot of ordinary light at the position of the gamma-ray burst. A few weeks later both the Hubble telescope and ground-based telescopes found a faint visible glow precisely where the now-vanished burst had been. It looked like the ordinary glow of a distant galaxy—the one, presumably, that had emitted the sudden burst.

On May 8, BeppoSAX pinpointed a second burst that nailed the case shut.

This time the world's most powerful optical telescope, the Keck telescope in Hawaii, was able to spread the visible-light afterglow into a spectrum. Superimposed on the spectrum were dark absorption lines, caused by gases in a cloud somewhere between the burst and Earth—about 7 billion light-years from Earth, according to astronomers at Caltech. That convinced pretty much everyone in the “bursts are nearby” camp that the explosions—or at least some of them—were actually very distant.

Meanwhile, astronomers at the Very Large Array radio telescope in New Mex-

ico were detecting the burst's radio-wave aftermath, another first. The radio emissions flickered dramatically at the outset, apparently because of the shifting gases they were passing through—just as starlight twinkles from its passage through Earth's atmosphere. But later the flickering stopped. That suggested the source of the burst had grown larger—the analogy would be a planet, which looks larger in the sky than a star and doesn't twinkle as much as stars. Combined with the fact that bursts seem to evolve from energetic gamma rays to X-rays to visible light, which means they cool off over time, the

radio data supported the idea that they are huge fireballs, expanding at near-light-speed and cooling as they go.

The ultimate cause of the fireball, though, is still a deep mystery. So far the leading candidates are the merger of two neutron stars and the swallowing of a neutron star by a black hole. For his part, Paczyński favors a sort of super-energetic supernova explosion. But it's still too early to tell. “These discoveries by BeppoSAX were a great breakthrough,” says Paczyński, “but we badly need more data.” Over the next few years, satellites should provide them.
—Sam Flamsteed

How Dry the Moon?

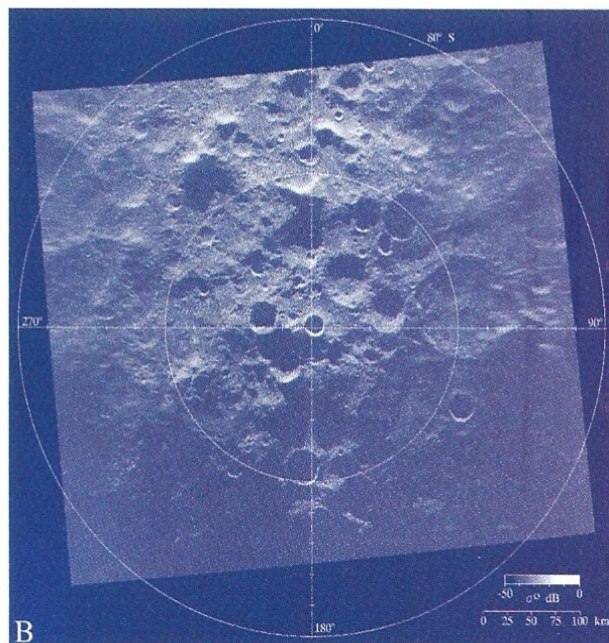
IS THERE ICE on the moon? When the spacecraft *Clementine* bounced a radar beam off the moon's poles in 1994, the echoes from some of the deep, permanently shadowed craters did seem to show the signature of ice—left over, perhaps, from long-ago cometary impacts. But last June, astronomers using the giant radar telescope at the Arecibo Observatory in Puerto Rico said they could find no sign of that ice.

Donald Campbell of Cornell and his colleagues made a radar map of the moon's poles that showed features as small as 400 feet across, a thousand times

sharper than *Clementine*'s view. Only a few small spots showed an icelike radar signature. And when Campbell compared the map with photographs of the moon, most of those spots turned out to be in sunlight and thus would have been too warm to hold ice. Campbell

Through Arecibo's eyes: Ice-free craters on the moon's south pole.

thinks the signal came from rough surfaces inside the craters, which distort radar in a manner similar to ice. There are still some deep craters that neither *Clementine* nor the Arecibo telescope could get a good angle on, he says, “but if *Clementine* had seen anything, we



THE BIG WHIMPER Cosmologists spend most of their time brooding on the beginning of the universe, but astronomer Fred Adams of the University of Michigan at Ann Arbor decided to calculate the future as precisely as standard cosmology and physics will allow. Last January, Adams and his colleague Greg Laughlin reported that the kind of universe we know—one dominated by bright stars and galaxies—is just a cosmic blip, albeit one that will last some 100 trillion years. By then, even the longest-lived stars will have burned out, and the universe will consist of black holes, dark brown dwarfs, and ever-cooling white dwarfs. That will not be the end, though. Dwarf stars, like all ordinary matter, are made of protons—which particle physicists believe last for only 10^{38} years or so. (That's 1 with 38 zeros.) If so, all the dwarf stars and all their protons will fall apart by 10^{40} years from now. There will still be black holes—but black holes are thought to evaporate. Although the process is slow—very slow—by 10^{100} years from now, there should be nothing left but a smattering of electrons, positrons, neutrinos, and photons skittering across space. What will this ultimate “Dark Age” be like? “The universe doesn't end, and complex physical processes don't end,” Adams says. “We're more limited by our lack of imagination in thinking this far into the future than we are by a deficit of interesting physical processes.”
—Jeffrey Winters

should have seen it, too. My feeling is that if there were any ice on the moon, there would be more than a puddle or two hiding in the corners.”

The *Clementine* researchers, however, stand by their results—and they're count-

ing on another spacecraft, the *Lunar Prospector*, to settle the matter. Scheduled for launch in January, that probe will map the chemical composition of the moon from an orbit over the poles.

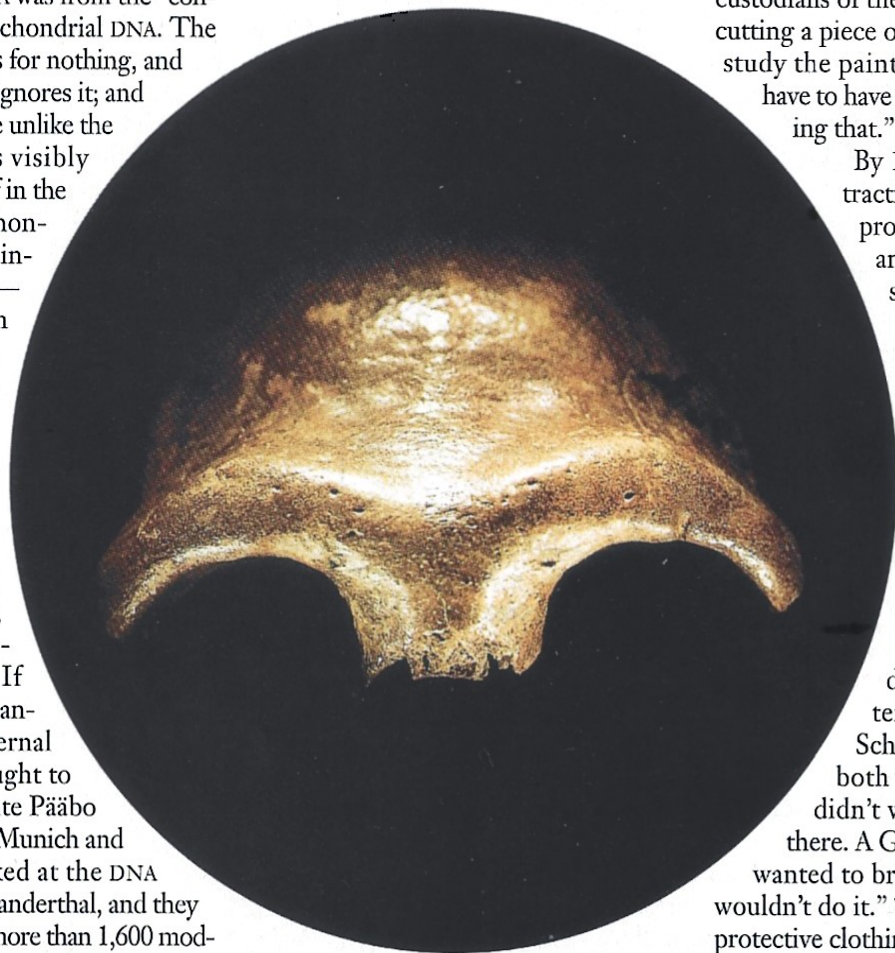
—Shanti Menon

Not Our Mom

A SMALL STRETCH of DNA from a Neanderthal bone was described this past year, and it doesn't look like ours. The bone was the right humerus, or upper-arm bone, of the Neander Valley skeleton itself, discovered near Düsseldorf in 1856; the DNA was from the "control region" of mitochondrial DNA. The control region codes for nothing, and so natural selection ignores it; and sex does too, because unlike the DNA that makes us visibly who we are, the stuff in the cell nucleus, mitochondrial DNA is passed intact from mother—and only from mother—to child. In theory, the control region comes to each one of us out of the deep past, like a taste for chicken soup, via an endless bucket brigade of mothers, altered only by random mutations. If some of us had a Neanderthal in that maternal line, her imprint ought to be discernible. Svante Pääbo of the University of Munich and his colleagues looked at the DNA from their single Neanderthal, and they looked at DNA from more than 1,600 modern Europeans, Africans, Asians, native Americans and Australians, and Oceanians. They saw no evidence of a relation.

The work was widely hailed as a technical triumph—reassuring in a year

when earlier reports of far more ancient DNA from insects in amber seemed to be crumbling (see story on page 47). Few labs besides Pääbo's, it seems clear, would have been able to extract the Neanderthal DNA from liquefied bone samples that



contained only some 50 copies of the target molecule. A graduate student named Matthias Krings did the hard work—amplifying the scarce DNA by means of the polymerase chain reaction, cloning it, and finally determining its sequence. "It was Krings who put in the 100-hour weeks," says Ralf Schmitz of the Rheinisches Amt für Bodendenkmalpflege, an agency responsible for archeology in the Rhineland.

"When he saw there might be something in there,

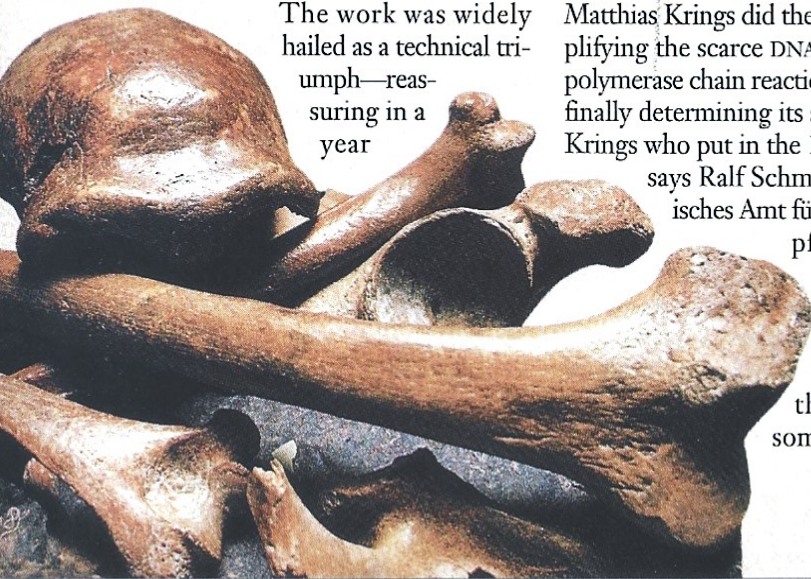
he just kept working until he was sure."

But it was Schmitz, a young archeologist, who made the project happen in the first place. In 1991 the Rheinisches Landesmuseum in Bonn authorized him to organize new studies of its prize fossil. Schmitz got in touch with Pääbo, who had extracted DNA from a 30,000-year-old horse buried in permafrost. At first Pääbo was discouraging: the chances of getting DNA out of a Neanderthal that was anywhere from 30,000 to 100,000 years old and that had not been frozen, he said, were very slim—too slim to convince the custodians of the fossil. "It's as if you're cutting a piece out of the Mona Lisa to study the paint," says Schmitz. "You have to have good arguments for doing that."

By 1996, though, gene-extraction techniques had improved, Pääbo was willing, and Schmitz got permission. In June of that year, he and Heike Krainitzki, a professional bone preparator, entered the steel vault where the bones are stored in a steel box in a steel cabinet—the Landesmuseum keeps only the skullcap with the famous browridges on display. "The nervous tension was enormous," Schmitz recalls. "We were both very tense. Krainitzki didn't want anyone else to be there. A German TV network had wanted to broadcast it live, but she wouldn't do it." The two of them wore protective clothing and surgeons' masks to avoid contaminating the bone. With a goldsmith's saw Krainitzki cut a half-inch thick, eighth-of-an-ounce, half-moon slice from the right humerus—the bone that X-rays and other tests had shown was best preserved. She and Schmitz then immediately carried the slice to Munich. There Krings drilled tiny samples from the cortex; the hard calcium carbonate in that outer layer offers DNA more protection against the outside world than it gets in the marrow.

Five months later Schmitz was back

Sixteen bones were found in the Neander Valley in 1856, including the skullcap (above).



in Munich again. By then, after all those hundred-hour weeks, Krings had extracted a bit of DNA that he thought was Neanderthal. He was now repeating the whole experiment with a separate hundredth-of-an-ounce bit of bone drilled from that half-moon slice. If he got the same DNA sequence again, he would be virtually certain he was not looking at a modern human contaminant. The results, Schmitz remembers, came in one November evening at 10:14 P.M. "It felt as if we had climbed Everest," he says. Later there would be another occasion for celebration: the results were confirmed by an independent laboratory, that of Mark Stoneking at Penn State, which got the same sequence from another bit of the Neanderthal bone.

Careful controls like that seem to have convinced the researchers' peers, after the paper was published last July, that Krings and his colleagues did indeed have the first bit of Neanderthal DNA and the oldest bit of DNA ever extracted from a human being. What sort of human the Neanderthal was, however, remains subject to debate. There are two main schools of thought. One holds that Neanderthals are our ancestors, or rather

the ancestors primarily of modern Europeans; in this view modern humans evolved from archaic ones such as Neanderthals in different parts of the world simultaneously, all the while exchanging enough genes to remain part of the same species. The other view is that Neanderthals were a separate species that were replaced, after little or no fraternization, by modern humans, who began migrating out of Africa around 100,000 years ago.

The Neanderthal DNA does not resolve the issue—but it suggests Neanderthals were indeed a separate species, and thus it favors the out-of-Africa hypothesis. Krings's 379-nucleotide sequence differed at 27 positions, on average, from the modern human sequences, and it was no closer to Europeans than to any other moderns. Among themselves the modern sequences differed by an average of only eight places. Picture a crowd of modern humans huddled around a campfire, with nobody more than eight yards from the center; then the Neanderthal is 27 yards away, well outside the circle, in the shadows at the edge of the woods. By Pääbo's and Krings's calculations, *Homo sapiens* and *Homo neanderthalensis* must have evolved sep-

arately for more than half a million years to have become so different.

Of course, the researchers have only looked at one bit of DNA from one Neanderthal. Only when they or others have compared it with DNA from a second Neanderthal will the Munich result be fully convincing. It is fitting, though, that the first Neanderthal DNA came from the first Neanderthal—and even from one of the bones that stayed the shovels of the miners in 1856, after they had already unwittingly tossed the skullcap and other bones out of Little Feldhofer Cave, down into the valley of the Düssel River. There is no Neander River, you see; the valley got its name in the late seventeenth century from a preacher and poet who often went there, a man named Joachim Neumann. In English his name would be Newman, but in the fashion of his day Neumann translated it into Greek, and it became Neander. A century and a half later, by a remarkable coincidence, the New Man Valley yielded a truly new man—a separate species of human, it now seems. It is wonderful, really, that after another century and a half, the Neanderthal Man himself should once again be in the news. —Robert Kunzig

SON OF CHEDDAR MAN The village of Cheddar, in the picturesque hills of Somerset in southwest England, is noted, of course, for its cheese; for the caves at Cheddar Gorge; and for Adrian Targett, a history teacher at Kings of Wessex Community School. Targett found out last March that he is related to 9,000-year-old Cheddar Man, the most complete ancient skeleton ever found in Britain.

A local TV company working on a documentary about the historic area had contacted Bryan Sykes, a geneticist at Oxford, to see if he could extract any DNA from Cheddar Man. Sykes was interested in comparing the genes of modern Britons to the preagricultural hunter-gatherers of Cheddar Man's time, so the project suited him perfectly. The producers then asked Targett to find local students willing to be part of the sample modern population. To show his students that the method of DNA sampling, a cheek swab, was painless, Targett himself participated.

After analyzing a 400-nucleotide sequence of mitochondrial DNA in the samples (from the same "control region" that was extracted from the Neanderthal Man), Sykes

found that Targett and Cheddar Man differed at only one spot. The two must have shared a maternal ancestor, perhaps someone as close as Cheddar Man's mother. "He's clearly quite closely related," says Sykes. Targett, however, knew nothing of this until the results were revealed to him and his class on camera. "It was a bit surprising," he says. "The presenter said 'We have a result,' and he turned toward me and said 'and it's you.' At least I didn't say anything that had to be deleted out of the recording."

Finding a match for Cheddar Man wasn't totally unexpected, says Sykes, who estimates that about 1 percent of the British population carries a similar bit of DNA. What's surprising, but apparently coincidental, is that Targett lives just half a mile from the cave where Cheddar Man was discovered in 1903. "I applied for 50 teaching jobs all over the country, and I happened to get the job here," Targett says. He's never seen the actual skeleton of his ancestor at the British Museum in London (and has no plans to reclaim it), "but I've become closely acquainted with the replicas," he says, "because I keep being asked to be photographed next to them." —Shanti Menon



Out of Africa and Back

THE OUT-OF-AFRICA theory may be in the ascendant, but it got a little more complicated this past year. Geneticist Michael Hammer of the University of Arizona in Tucson reported evidence that after the initial exodus roughly 100,000 years ago, some human ancestors in Asia may have migrated back to Africa, leaving a genetic stamp on populations there that was later carried out of Africa again on subsequent migrations.

Hammer's argument is based on his analysis of a small stretch of DNA called YAP. Located on the Y chromosome, it is the male equivalent of mitochondrial DNA—it doesn't code for a protein, and it passes from father to son altered only

by a steady accumulation of random mutations. As a result, populations that have interbred recently will have more similarities in their YAP DNA than will populations that have long been separated. By looking at the differences in YAP DNA in modern populations—1,500 men from 60 populations in Europe, Asia, Africa, and Australia—Hammer was able to reconstruct a paternal family tree for the Y chromosome.

He found that the YAP DNA of some modern African men seems to have descended from much older YAP in Asian populations. "This leads us to believe that there was a significant period of evolutionary time when people in Asia evolved

their own types of Y chromosomes, and then later spread that to Africa," says Hammer. After the African exodus, he thinks, early modern humans spent thousands of years living "somewhere north of the Himalayan Mountains but south of Siberia" before some returned to Africa between 50,000 and 10,000 years ago.

A sojourn in Asia is also supported by the work of population geneticist Rosalind Harding at Oxford. Harding conducted a study similar to Hammer's but looked at a different stretch of DNA from populations in Africa, Asia, Australia, Papua New Guinea, and Europe. She found evidence for a migration from Asia back to Africa more than 50,000 years ago. Instead of the simple picture of modern humans originating in Africa and then colonizing the rest of the world, she says, the new evidence presents a view of human origins that is more messy and confusing—and therefore probably more realistic. "There was a lot of diversity generated in Asia," she says, "and some of it went back to Africa." —*Kathy A. Svitil*

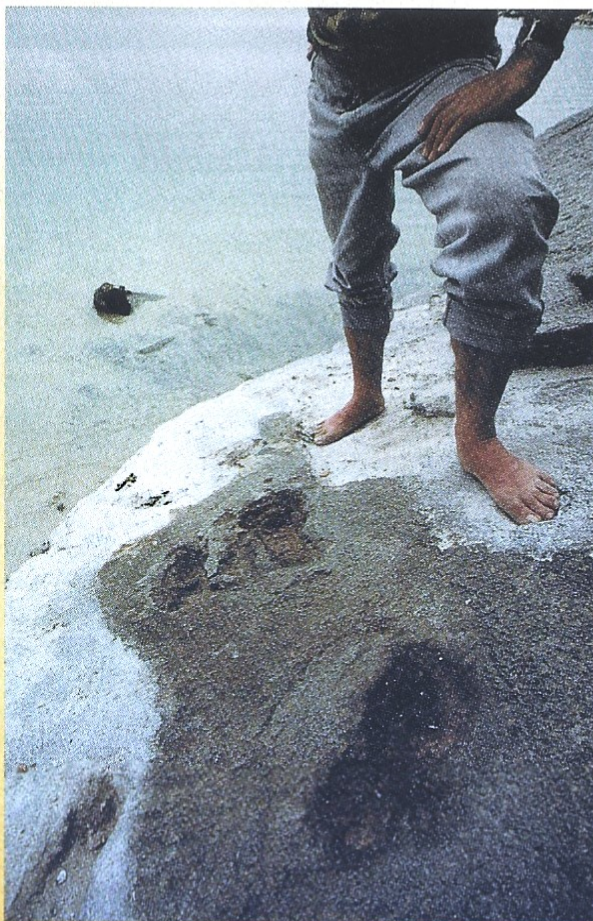
FOOTPRINTS FROM THE HUMAN DAWN One day after a heavy rain, a small person—a woman or a teenager—walked across a wet sand dune toward what is now Langebaan Lagoon near Cape Town, South Africa, and turned to walk east along the water's edge. The footprints that person left behind, around 117,000 years ago, are the oldest known tracks made by a modern human. Geologist David Roberts spotted the prints in late 1996 while studying the dunes. His colleague Lee Berger, a paleo-anthropologist at the University of Witwatersrand in Johannesburg, announced the discovery in August.

The prints have been dated by several methods that converge on 117,000 years. "The arch, the ball of the foot, everything says these are anatomically modern human footprints," says Berger. The stride length and the depth of the prints suggest they were made by a person just over five feet tall. At one point he or she curled a big toe into the wet sand. "It's a tremendous thing to think that 117,000 years ago, a person was squishing through that wet sand just like we do today,"

says Berger. He admits he tried to fit his foot into one of the dainty prints—but only after putting a preservative in first. "Come on, could you resist?" he asks.

The two and a half steps, one of only three sets of human tracks in the African fossil record, were preserved when loose, dry sand blew over the wet, packed tracks, after which the underlying sand turned into rock. Berger plans to excavate more of the trackway, which is cut off by the sheer face of a dune. "I hope she tripped a few feet back so we can see her splayed out like a sand angel," he jokes.

Tools and bones from nearby sites show that the earliest modern humans originated in this area before—according to the out-of-Africa theory—they spread across the globe. "This might sound funny coming from a scientist," says Berger, "but I think the emotive impact of these footprints is the most powerful message. It's incredibly exciting to put your foot into that print. This is from the time period from which every living human inherited his genetic potential. This is in fact one of us." —*Shanti Menon*



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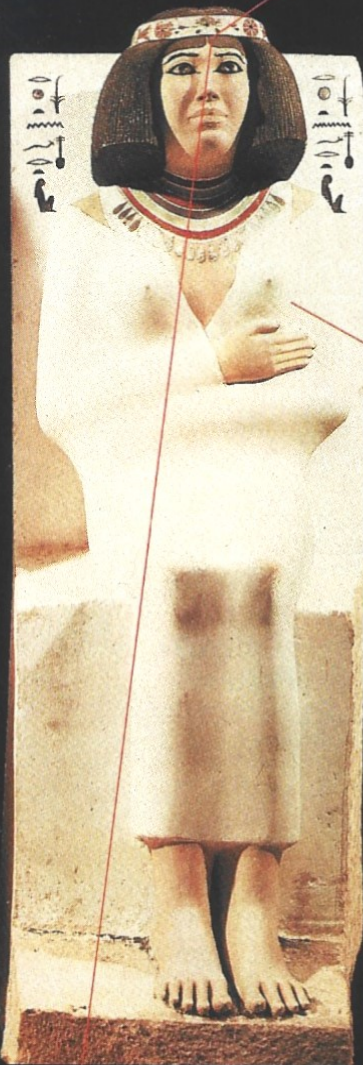
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The Genes of 1997

A slew of genes linked to brain disorders were among the highlights of another rich year in medical genetics:

EPILEPSY AND MENTAL RETARDATION: Usually, mutant genes on the X chromosome affect only men, because they, unlike women, don't carry a second copy that can compensate. This past year researchers identified a mutant gene on the X that causes epilepsy and retardation only in women. Male carriers of the mutation are somehow spared its bad effects, but they pass on the disorder to their daughters.



HEROIN ADDICTION: Some cases have been linked to a gene on chromosome 11 that codes for a dopamine receptor on brain cells. An abnormally long form of the gene has turned up not only in drug addicts but in other people who exhibit novelty-seeking behavior.

PARKINSON'S DISEASE: A mutant gene on chromosome 4 may give rise to some early-onset cases. The gene codes for the brain protein alpha-synuclein; a mutation is thought to produce misfolded proteins, which accumulate in the brain and may kill neurons that make dopamine. Loss of that neurotransmitter leads to tremors and muscle rigidity.

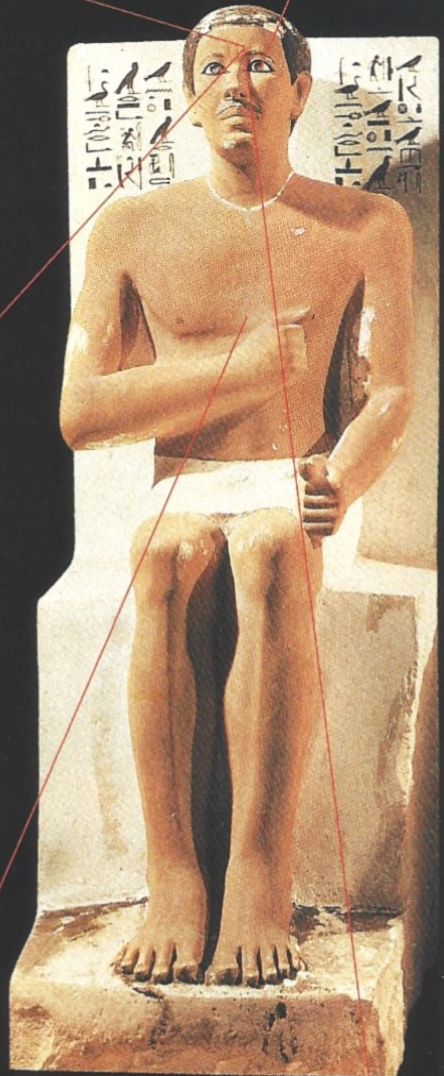
BOXER BRAIN: Boxers with chronic brain injury—which has symptoms similar to Alzheimer's and Parkinson's diseases—are far more likely to carry a gene on chromosome 19 that has also been linked to Alzheimer's. Repeated blows to the head may trigger the deposit of beta-amyloid, a brain protein associated with Alzheimer's, and carriers of the gene may be less able to repair such injuries.

BREAST CANCER: Exposure to estrogen is a known risk factor for breast cancer. This past year researchers found that women with a variant form of a gene involved in estrogen production have over double the risk of developing advanced breast cancer—perhaps because they make more estrogen. The gene variant, on chromosome 10, may contribute to about 30 percent of all cases of the disease.

FAMILIAL MEDITERRANEAN FEVER: This disorder, which causes arthritis as well as fever, is prevalent among North African Jews, Armenians, Turks, and Arabs. This year researchers not only pinpointed the FMF gene on chromosome 16; they also traced the origin of two disease-inducing mutations back to two people who lived in the Middle East as long as 40,000 years ago. The gene codes for a protein in white blood cells; when mutated, it induces bouts of fever.

FETAL ALCOHOL SYNDROME: High doses of alcohol early in pregnancy switch off a gene that controls the development of the brain, heart, limbs, and skull—of mouse embryos, anyway. But since the same gene is found in humans on chromosome 5, the researchers who made the discovery think it may account for the malformations characteristic of fetal alcohol syndrome.

GLAUCOMA: A mutant gene on chromosome 1 leads to juvenile-onset cases and some adult cases of this disease, which causes vision loss. The defective protein it makes may gum up the meshlike filter that drains water from the eyeball, allowing fluid to build up and damage the optic nerve. The discovery will permit doctors to look for the mutation in relatives of people with glaucoma and to treat them if necessary before they, too, go blind.



OBSESSIVE-COMPULSIVE DISORDER: Between 1 and 3 percent of the population feel pathologically compelled to repeat certain behaviors, such as washing their hands. This year a gene on chromosome 22 was linked to some cases of the disorder in men. The gene codes for an enzyme that breaks down dopamine and another neurotransmitter, norepinephrine, after they have carried a signal across the gap between brain cells. Men with OCD are more likely to have a less active version of the enzyme—and thus perhaps an excess of the neurotransmitters.

—Josie Glausiusz

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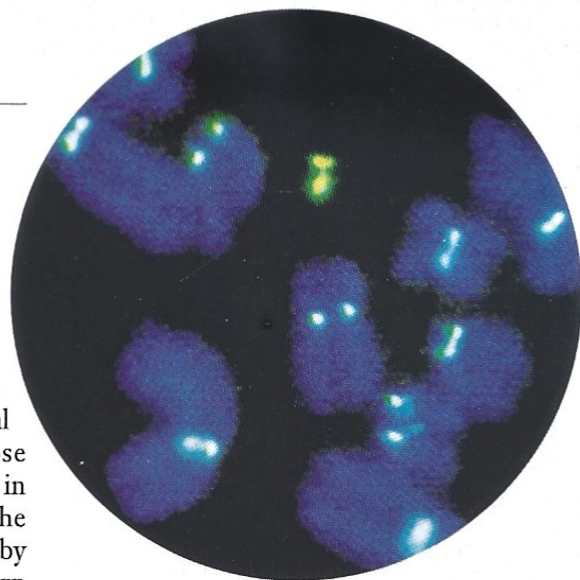
A Man-Made Chromosome

ALTHOUGH DOZENS of genes are identified every year, along with the flaws in them that cause disease, gene therapy is still rare. The biggest problem is how to deliver an intact gene into the body of a human who needs it. Viruses are one vehicle, but often they can't carry long human genes, and when they can the genes don't always produce consistent levels of protein. Last spring researchers in Ohio announced the creation of a promising new gene carrier: a human artificial chromosome (HAC) that behaves just like a natural one. It is duplicated and passed along with every cell division—just the talent necessary for it to survive in the body and provide long-

term relief from a genetic disease.

A chromosome is more than just DNA; the DNA is wrapped around ball-shaped proteins called histones. Researchers have already created artificial chromosomes in yeast, but those wouldn't reproduce in a human cell, in part because yeast histones aren't the same as human ones. The team led by Huntington Willard at Case Western Reserve University School of Medicine avoided this problem by giving naked DNA to cultured human cells, letting them provide their own histones.

But the researchers couldn't use just any DNA. There are three key stretches of DNA on a human chromosome, and

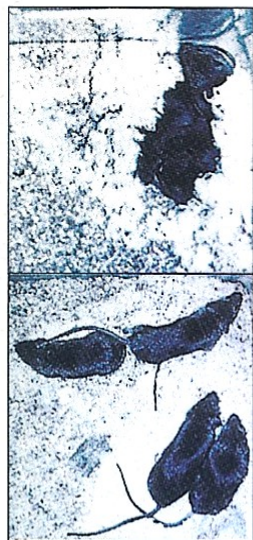


In the black, you see a HAC: The artificial chromosome among bigger, natural ones.

without these the chromosome will not reproduce properly. The first is an origin of replication, where the two spiral strands unwind so they can be copied. The second stretch is the telomere, a protective cap that prevents the ends of chromosomes from shortening every time the cell divides. The third stretch is the centromere, the little knot that joins the two identical copies of each chromosome after replication, ensuring that each daughter cell will get one copy as the cell divides.

Telomeres and centromeres both consist of many repetitions of a single short DNA segment. Willard's team knew how many in the case of telomeres and managed to synthesize a long enough sequence. In the case of centromeres they had to guess, attaching many of the short DNA segments end to end and hoping to make the chain long enough. To make the origins of replication, whose sequence is unknown, the researchers guessed again, using segments of human DNA that they suspected contained the right sequence. Finally they threw a mix of all three key DNA elements into human cells.

Their educated guesses proved lucky: a look at the cells under a microscope revealed a stable, if minuscule, HAC, about a fifth to a tenth the size of natural human chromosomes. That is considerably longer than any viral genome, though, and long enough to carry entire human genes as well as the sequences around them that regulate how much protein is made. And since the HAC carries only hu-



LONER MICE Clinical geneticist Anthony Wynshaw-Boris never expected to dabble in rodent psychiatry. But he did more than dabble when he created mice lacking a key developmental gene. In September his group at the National Human Genome Research Institute in Bethesda, Maryland, announced that those mice show behavioral abnormalities similar to ones seen in human disorders such as schizophrenia, autism, and Tourette's syndrome.

The gene in question, *Dishevelled-1*, is so essential to development that it is found in animals as distantly related as fruit flies, mice, and humans. When the gene is removed, or 'knocked out,' from fruit-fly embryos, larvae emerge with scrambled body parts. Wynshaw-Boris and his colleagues had expected equally drastic effects in mice.

But the mice appeared completely healthy—even in the anatomy of their brains, where the *Dishevelled-1* gene is very active. Eventually, though, the researchers noticed

something odd: all the knockout mice had whiskers, while none of the normal mice did. Since the barbering of whiskers is a common social behavior in this strain of mice, Wynshaw-Boris and his team took a closer look. Video recordings revealed that the mutant mice did not groom each other much and did not huddle in fluffy nests—in short, they did not socialize the way normal mice do.

They also flunked a test that stumps schizophrenics. Normal mice and normal humans are far less startled by a sudden loud sound if it is preceded by a soft one. But the mutant mice—like schizophrenics and other psychiatric patients—were just as startled with or without an alerting sound. In human patients, that performance is interpreted as symptomatic of an inability to filter incoming information and recognize when it's worth attending to.

Other researchers are now looking for evidence that the *Dishevelled-1* gene is indeed mutated in psychiatric patients—although what it does in the brain remains a mystery. "We think *Dishevelled* would be a candidate gene for several human psychiatric disorders," says Wynshaw-Boris. Meanwhile, his strange mice may lead to better treatments for those disorders: they make good laboratory models for testing new drugs.

—Unmesh Kher

man DNA, it is far less likely than a virus to trigger an immune response in the patient. On the other hand, whereas viruses can easily slip into a patient's tissues, artificial chromosomes can only be put into cells that can be removed from the body and then reintroduced—blood cells,

for example. "I would not like to pre-judge what it will or will not be useful for," says Willard, "but I think the blood diseases—such as sickle-cell anemia and hemophilia—are the most obvious ones to tackle at the moment."

—Unmesh Kher

MY HEART I GOT FROM DADDY Everybody agrees that being socially skilled means—in part at least, nowadays—being sensitive to another person's feelings. And most people would probably agree that women tend to be more socially skilled than men. What most people probably wouldn't agree on is that the skill is genetically based. But last June child psychiatrist David Skuse of the Institute of Child Health in London and a team of psychologists and geneticists proposed exactly that: genetic information influencing social skills, they claim, lies somewhere on the X chromosome. Even more surprising, these skills seem to be handed off to women by the X chromosome they inherit not from their similarly gracious mothers but from their clueless fathers.

Skuse came to this tentative conclusion after studying 80 females with Turner's syndrome, a genetic disorder in which a girl inherits only one X chromosome from either her mother or her father. Turner's girls lack ovaries, but they don't look much different from normal girls, who inherit an X chromosome from both parents. In most respects, including verbal intelligence, they are normal.

Except that psychological tests suggest many of them have poor social skills. Skuse decided to investigate whether inheriting an X from the mother or from the father had any influence on that problem. The idea isn't as strange as it sounds. A handful of genes have been identified whose expression is dictated by parental origin; they are called imprinted genes. So far, though, nobody has found evidence of an imprinted gene on a human sex chromosome.

A close look at the girls' X chromosomes showed that 55 had a maternally derived X chromosome and 25 had a paternally derived X. When Skuse gave the parents a questionnaire designed to measure their child's social skills, girls with the maternal X had scores indicating poor social skills; in general, they were unaware of others' feelings and had trouble picking up social signals, at least according to their parents. In contrast, the girls with the paternal X were far more socially adept. Moreover, when Skuse tested the girls' ability to concentrate by asking them to substitute ones for twos and twos for ones in a string of ones and twos, he found that the girls with the maternal X were less able to concentrate on this unusual task. He concluded that their thinking was more impulsive, which might contribute to their social difficulties.

The differences between the two Turner's groups, says Skuse, hint that somewhere on the X lies a gene (or genes) influencing social ability—one that is expressed only if it is inherited from the father. The father, in turn, must get the gene from his mother because men always inherit their X chromosome from their mothers and their Y chromosome from their fathers. In men, however, the gene does not seem to be turned on; boys score badly on Skuse's social skills questionnaire compared with normal girls. Only girls, who inherit an X from their fathers, express the gene. In Skuse's scenario, the "social skills" trait passes from mother to son to granddaughter, but with the male acting only as an asymptomatic carrier.

Skuse thinks this peculiar pattern of inheritance—if it does turn out to be real—has evolutionary significance. "The imprinting mechanism evolved for a good reason," he says. "If it happened, it meant that mothers now conferred an advantage on their sons." Why would it be advantageous for boys not to express this "social skills" gene? "This is where we enter a very speculative realm," says Skuse. "I really don't know. It must have enabled those males to become more dominant. And I suspect it may also have enabled a more uniform social structure to be imposed on a group of males who would have had to learn social skills rather than develop them intuitively."

—Josie Glausiusz

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UNLIKE EXPLORERS OF OLD, who could name newly found lands whatever they wanted, the researchers who discover new elements have to submit their choices to a committee before they can leave their mark on the periodic table, the

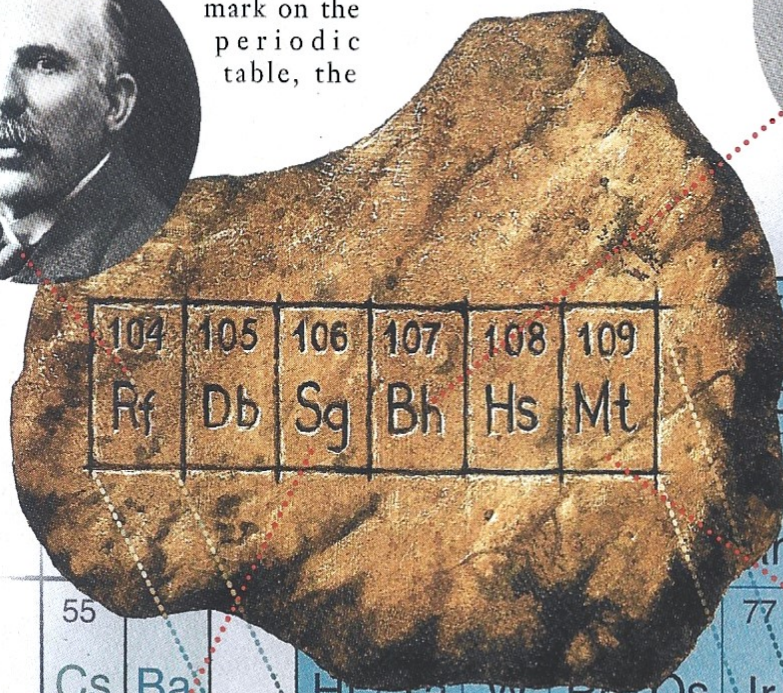


produced about 30 years ago, but the naming process was drawn out by competing claims from laboratories in the United States, Germany, and Russia. A joint commission of physicists and chemists sought a compromise that would satisfy all.



covered the atomic nucleus. The Germans wanted to enshrine Lise Meitner, codiscoverer of atomic fission, as well as one of their labs in the state of Hesse. And both the Germans and Russians pushed for Niels Bohr. "I suspect the feeling between the United States and Russia is a relic of the cold war," says Jeffery Leigh of the chemists' union. "In the end, this is a compromise that doesn't satisfy anybody completely."

At least Seaborg, the Nobel laureate discoverer of ten elements, including plutonium, has reason to



map of the
chemical world.

In September the International Union of Pure and Applied Chemistry resolved the debate on six laboratory-made elements, assigning the names rutherfordium (Rf), dubnium (Db), seaborgium (Sg), bohrium (Bh), hassium (Hs), and meitnerium (Mt) to elements 104 through 109. (The numbers refer to the total protons in each element's nucleus.)

The first sample of rutherfordium was

Elements and eponyms
(clockwise from left): Glenn Seaborg, Ernest Rutherford, Niels Bohr, Lise Meitner.

The Russians gained recognition for work done at a laboratory in Dubna—to the dismay of the Americans, who dispute some of that lab's claims. The Americans wanted to honor 85-year-old Glenn Seaborg of the University of California at Berkeley, as well as Ernest Rutherford, the British physicist who dis-



be happy. "This is the greatest honor that I've ever received," he says. "One hundred years, a thousand years—there it is, still in the periodic table." Not only is Seaborg the first living scientist to have an element named after him, he's also the only person who could receive mail addressed only in elements: Seaborgium, Lawrencium (for the Lawrence Berkeley Laboratory where he still works), Berkelium, Californium, Americium. But don't forget the zip code.

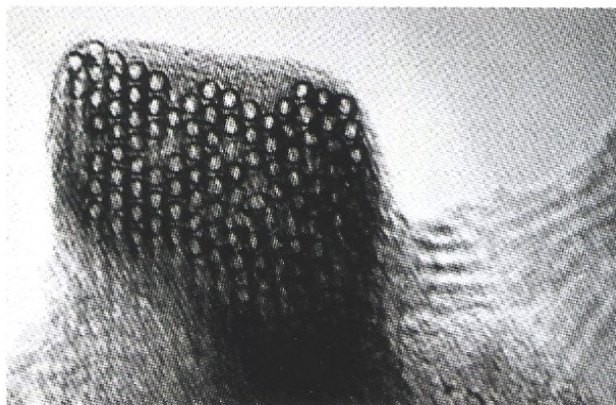
—Jeffrey Winters

Nanotanks

OVER THE PAST FEW YEARS chemists have discovered an assortment of oddly shaped carbon molecules, such as the microscopic tubes in these images. Last March, researchers at the National Renewable Energy Laboratory in Golden, Colorado, announced that they'd managed to use molecular tubes like these as miniature storage tanks for hydrogen gas. This seemingly esoteric stunt may have a very practical payoff: it could provide the means to safely store clean-burning hydrogen gas in a new generation of non-polluting vehicles. Says materials scientist Michael Heben, who worked on the project: "This points to the possibility of high-density hydrogen storage at room temperatures."

One of the drawbacks to using hydrogen gas, which liquefies at -423 degrees, to power cars and trucks is the difficulty of storing enough of it to provide the energy equivalent of a tank of gas.

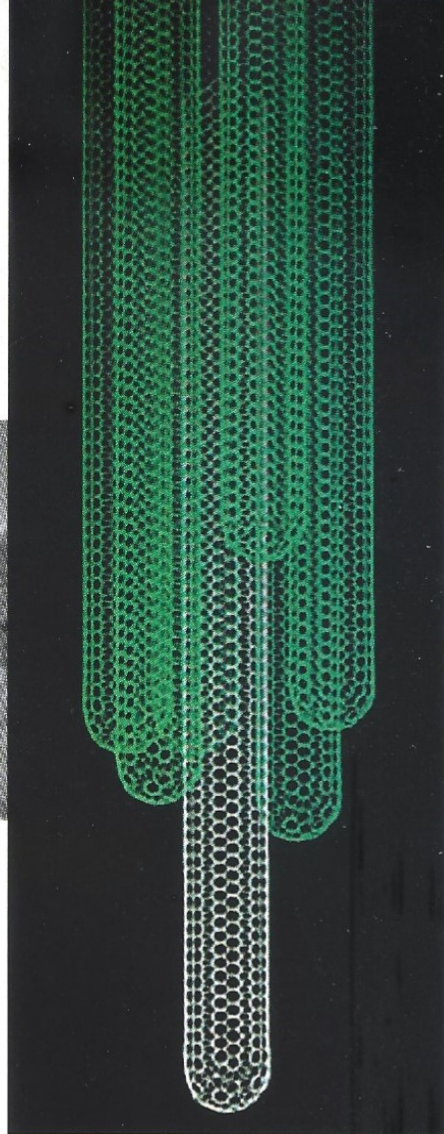
Cooling and liquefying the gas, for example, requires expensive and bulky equipment. But the Colorado researchers found that when hydrogen gas flows over carbon nanotubes, the tubes soak up the



Nanotanks of carbon, as seen by an electron microscope (above) and a computer (right).

gas like sponges. The researchers estimate that a gas-tank-size block of carbon tubes filled with hydrogen could power a typical car for 200 miles.

—Jeffrey Winters

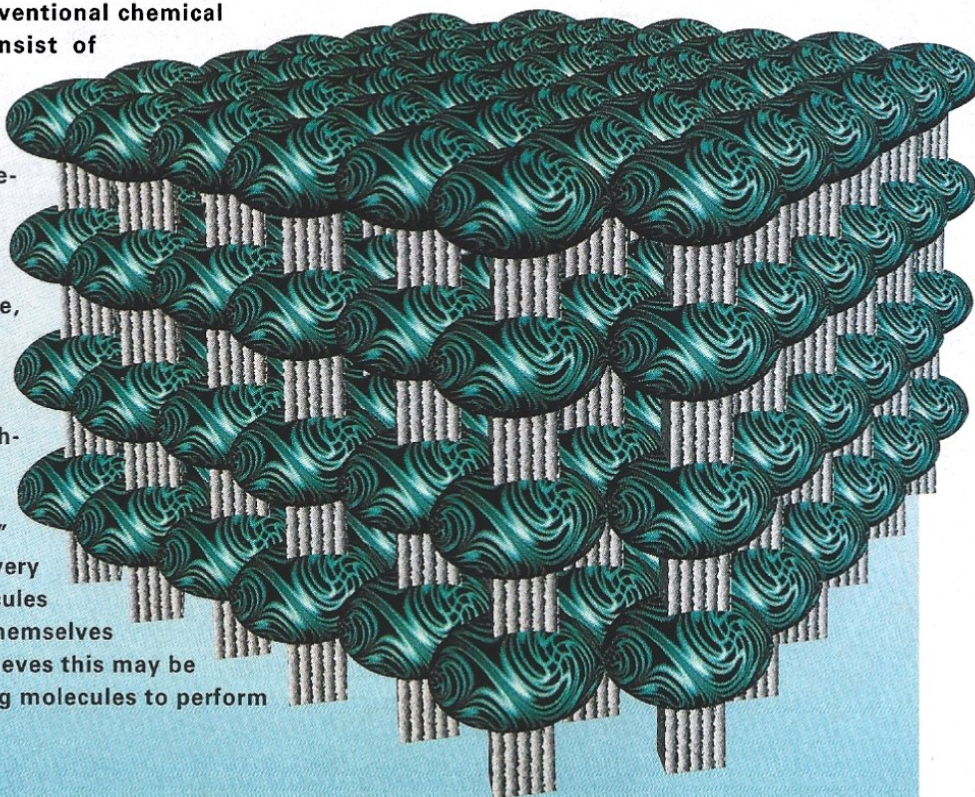


MAGIC MUSHROOMS It took Samuel Stupp years to build the layer cake of mushrooms you see here—or rather, to find a way to let it build itself. The building blocks, says Stupp, a chemist at the University of Illinois in Urbana-Champaign, are molecules called rodcoils, which he did build himself by conventional chemical methods. Rodcoil molecules consist of short chains of carbon: one end is a rigid rod while the other is a floppy ribbon. Stupp discovered that when he dissolved those molecules in a liquid, then let the liquid start to evaporate, the rods attracted one another and spontaneously formed a thick bundle, while the floppy ends formed a spongy dome over the bundle. And if he let the liquid completely evaporate, he got trillions of mushrooms nestled in neat layers.

"It's hard to synthesize big molecules using conventional chemistry," says Stupp, who reported his discovery last April. "But here you have molecules that are programmed to organize themselves into a nano-size object." Stupp believes this may be a step toward using self-assembling molecules to perform

complex tasks. He has already begun testing the mushrooms as a spray-on deicing chemical for aircraft. The stem end of the mushroom, says Stupp, would stick to the airplane, while the other would prevent the formation of ice crystals.

—Jeffrey Winters



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From German engineers, the Porsche Turbo of electronic shavers.

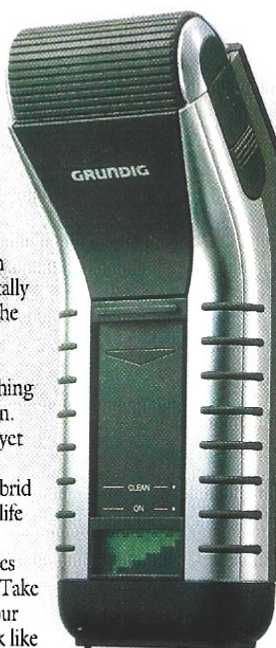
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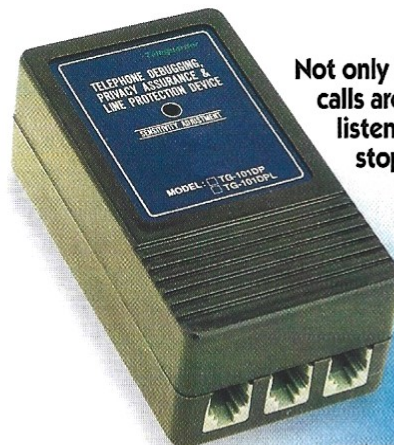
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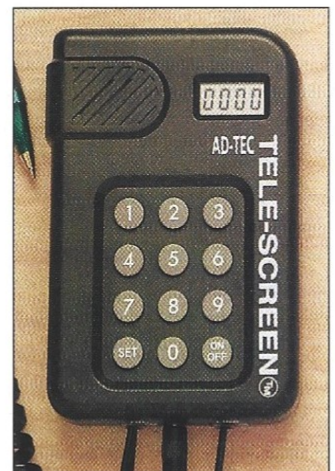
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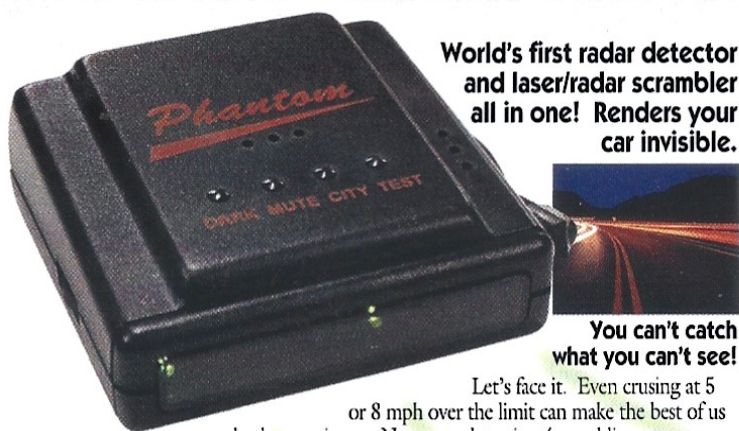
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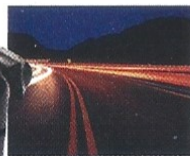
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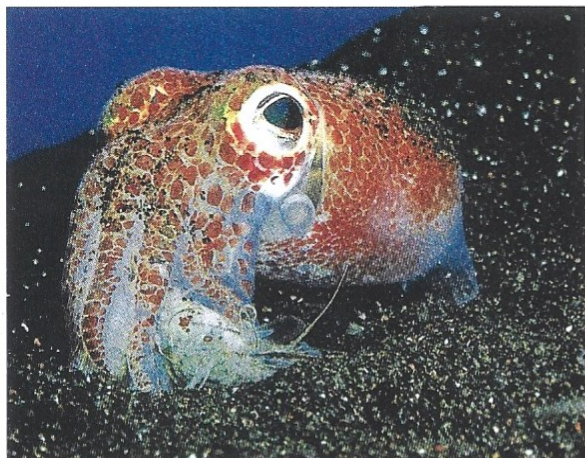
AT SOME POINT during the growth of an insect larva, a gene called Dll switches on and helps organize some of its cells into legs. If for some reason Dll is shut off, the insect will produce only stumps. In the early 1990s scientists were surprised to discover that almost identical copies of this gene can be found in mammals and other vertebrates—and that they too switch on as legs form. This was surprising for two reasons. For one thing, insects and vertebrates have radically different limbs: ours have bone inside and muscle outside, while bugs are the reverse—their flesh is protected by an armored exoskeleton. For another

thing, insects and vertebrates are only distantly related: our last common ancestor lived perhaps a billion years ago and was assumed to be limbless, like a flatworm. Researchers therefore imagined that the two lineages evolved their limbs—and the genes that build them—independently.

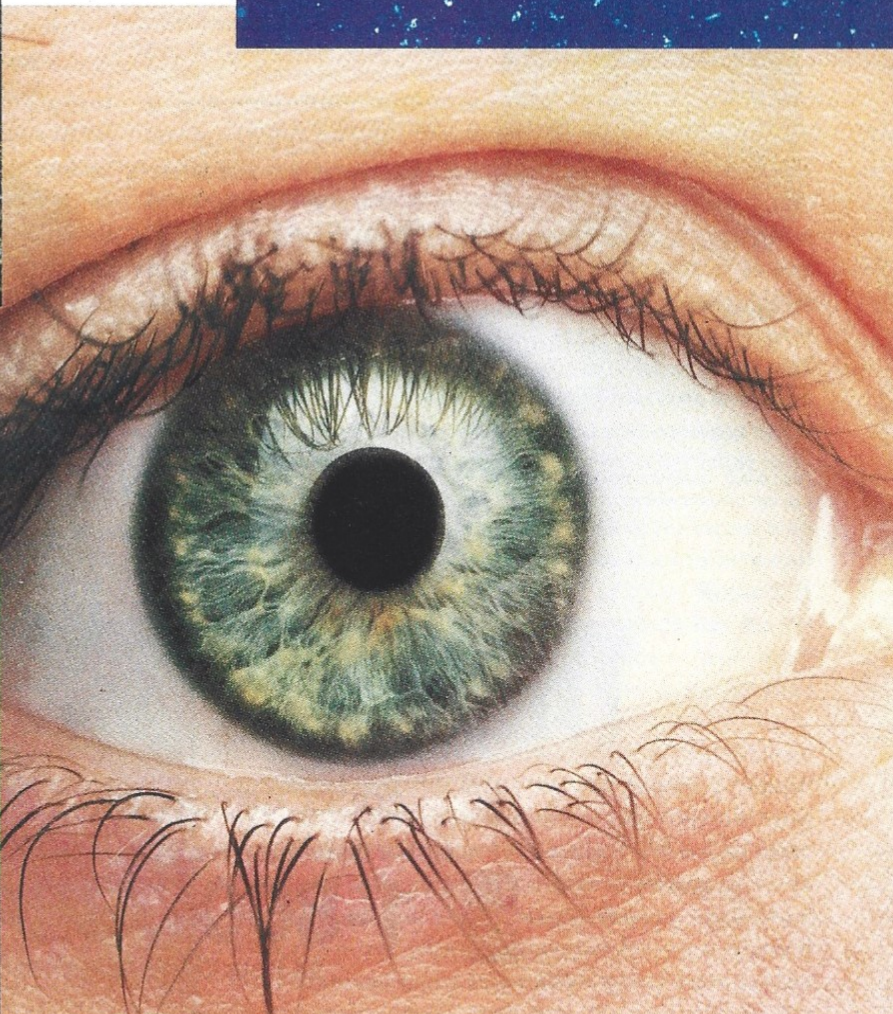
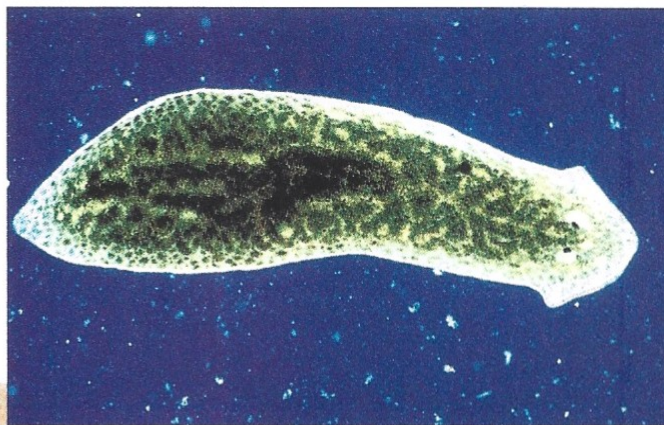
The Dll discoveries inspired a group of biologists led by Grace Panganiban of the University of Wisconsin and Steven Irvine of the University of Chicago to survey some of the other animals that also descended from that billion-year-old ancestor. They looked at odd little creatures called vel-

vet worms, which walk around on forest floors with fleshy pads. They looked at sea urchins, which are studded with little tubes that they use to roll around the ocean floor. They looked at sea squirts, which use a big, footlike projection to clamp onto coral reefs. Remarkably, as the researchers announced last May, Dll-like genes become active in the developing appendages of every animal they looked at.

Data pouring out of other labs suggest that all these animals are similar in other ways as well. Insects and people, for instance, also have very different eyes—ours focus light through a pupil onto a retina, while fly eyes are made of hundreds of honeycomb-



The same genes build eyes in flies, squid, flatworms (above right), and us.



shaped image sensors. Researchers had again figured that both groups evolved eyes on their own. But over the past few years several labs have shown that a number of key genes that produce vertebrate and insect eyes are almost identical—and last March it was reported that even squid use the same genetic equipment. Recent studies suggest that the development of certain features—head-to-tail body axis, back-to-belly orientation, and even the heart—is guided by the same

basic genes in a wide variety of animals.

At the very least, these results suggest that our billion-year-old ancestor already had those genes. Exactly what that ancestor looked like is a trickier question, though. Perhaps instead of limbs it had some other projections from its body wall, such as stalks alongside its mouth for feeding. Rather than an eye, it might have had a light-sensitive patch of cells on its skin. And rather than a heart, it might have had a confluence of blood

vessels. Only later did animals along different evolutionary branches use these genes to produce different kinds of limbs, hearts, and eyes. “We have this huge jigsaw puzzle and only a few pieces on the table right now, but the last common ancestor of insects and humans may have been more complicated than we previously thought,” says Panganiban. “We may be able to draw a picture of the common ancestor pretty soon, and it may not look like a flatworm.” —*Carl Zimmer*

ANCIENT HISTORY When Mary Schweitzer, a paleontologist at Montana State University, speaks at scientific conferences, she sometimes shows her audience how to find DNA from a dinosaur: “Keep your eyes open for one of these,” she jokes as she flashes a slide of the ideal specimen—a toy dinosaur embedded in amber.

But it now appears that even if Schweitzer were handed a *Velociraptor* trapped in a ton of amber, she wouldn’t be able to get any DNA. For the past few years, astounding reports in scientific journals (and magazines such as this one) have trumpeted the discovery of ancient genetic material in insects caught in amber millions of years old. But for many researchers, the notion is now pretty much dead. It appears that the fossilized tree resin isn’t such a fool-proof preservative as once thought. Pretty, yes; but an embalmer of ancient DNA, no. “A lot of the DNA you see in amber is some kind of highly modified ghost,” says Richard Thomas, a molecular systematist at the Natural History Museum in London.

Although there were several reports of discoveries of ancient DNA—particularly from amber—in the early 1990s, most subsequent attempts came up with nothing. No one expected getting DNA would be easy, but many researchers would have been more comfortable if these successes had been replicated even once. Recently Thomas and his postdoctoral researcher Jeremy Austin decided they would try to study the evolution of flies by examining specimens trapped in amber. They used a number of insect samples dating back 25 to 40 million years, including some from the same Dominican amber that had been the source of the first reports of successful gene recovery. They never got to study fly evolution—because, as they reported this past year, they could not find any DNA. Trying out many methods for isolating DNA on 15 samples, Thomas and Austin found nothing.

For many researchers the results of this notably rigorous and thorough research was the last straw for ancient DNA. It is such a fragile molecule, they argue, that it can’t hold up for more than 100,000 years, even in amber. (The Neanderthal DNA discovered this past year was only be-

tween 100,000 and 30,000 years old.) “Either we’re all incompetent or it’s extremely difficult to make it work,” says Thomas. To him, the supposed successes of the past may have been the result of stray DNA from living organisms that drifted through laboratories. Since the common technique for finding ancient DNA involves replicating numerous copies of gene fragments—through a process called the polymerase chain reaction—even a tiny bit of contamination might fool a researcher.

Not everyone agrees with Thomas’s gloomy conclusions. “I don’t think the book’s closed,” says Rob DeSalle, a molecular systematist at the American Museum of Natural



History who reported finding DNA from a termite trapped in amber in 1992—and who still stands by his claim. “The fact that they’re not replicated doesn’t invalidate these results.” Nevertheless, many labs that were in hot pursuit of ancient DNA, including DeSalle’s own team, have dropped the research; DeSalle says the payoff isn’t worth the enormous effort. Mary Schweitzer herself tried and failed to get DNA out of a well-preserved fossil of *Tyrannosaurus rex*. This year, however, she reported her success in isolating blood proteins, which are far sturdier. It’s always possible that some similarly encouraging research will emerge in the field of ancient DNA, but for the moment it seems on its way to becoming ancient history. —*Ann Gibbons*

Cretaceous Pompeii

AS LARRY MARTIN explored the barren hills of a remote corner of northeast China last March, it struck him that he was visiting a scene of mass death. Here, on the shores of an ancient lake, hundreds of birds, dinosaurs, fish, insects, and plants all died suddenly sometime between 130 and 110

million years ago. Perhaps they were engulfed in a cloud of ash or poisonous gas from a volcano—but today, in any case, their remains are so numerous and so well preserved that the site in the Liaoning Province is being called a paleo-Pompeii. “It’s as if they were frozen in time,” says Martin, a paleontologist at the University of Kansas in Lawrence.

The site has been known for years to local people, who have dug up fish and insect fossils to sell to collectors. But



Treasures from the Chinese fossil site include a dragonfly (right), a lizard and fish (middle), and a primitive bird known as *Confuciusornis* (far right).



The Chinese site has yielded amazing fossils including the dinosaur *Sinosauropteryx* (opposite and right), which some paleontologists think was covered in proto-feathers.

its importance wasn't recognized until recently when one lucky prospector hit pay dirt—layers of clay stone filled with hundreds of primitive birds and dinosaurs, including a small carnivorous dinosaur that some paleontologists have claimed had a crest of primitive feathers. (A debate is still raging over the issue.) The dinosaur was found just below the remains of two prehistoric birds—*Confuciusornis* and *Protarchaeopteryx*—that closely resemble the 150-million-year-old *Archaeopteryx* from Germany. With further study, one or both of them may challenge *Archaeopteryx*'s title as the most primitive known bird.

As word of the discoveries spread, Western paleontologists faxed scientists in China with requests to see the specimens. Martin, John Ostrom of Yale, and other members of an international team sent by the Academy of Natural Sciences in Philadelphia made the trek last spring and examined fossils so well preserved they could see an egg in one dinosaur's oviduct and a last meal of mammal in another's gut. And these fossils are just a fraction of the treasure buried at Liaoning—the remains come from several mass deaths that are layered in a 4,800-foot-thick bed of sediments. That means decades of work for paleontologists; the Americans are nearing an agreement to collaborate with the Chinese. "As I was retreating from those hills," Ostrom exults, "I realized that this is the most important earth science discovery in our lifetime." —Ann Gibbons



Tyrannosaurus Agonistes

EVER SINCE her discovery, the *T. rex* named Sue has suffered years of legal wrangling. Commercial fossil collector

land in South Dakota in 1990. Since the federal government had claims on the land, it confiscated Sue's skeleton, brought

Right: A dinosaur bone with signs of gout; left: Sue's skull.



Peter Larson found the skeleton—the best-preserved *Tyrannosaurus* specimen ever unearthed—on Indian reservation

various charges against Larson, and threw him in jail, from which he emerged last August. In October, Sue was auctioned

off at Sotheby's in New York for \$8.4 million to the Field Museum of Chicago, backed by McDonald's and Disney. The proceeds will go to the owner of the land, who had originally sold Larson the fossil for \$5,000.

This year also brought the news that in life Sue may have suffered from a different kind of agony: gout. Paleontologist Kenneth Carpenter of the Denver Museum of Natural History managed to make a cast of Sue's forearm and hand before the dinosaur was seized. When Ohio rheumatologist and paleopathologist Bruce Rothschild visited Carpenter and looked at the cast, he noticed a hole.

Not too many diseases cause small holes in bone; Rothschild immediately suspected gout. Birds and alligators get it, and they are the dinosaurs' closest living relatives. Rothschild went to the Royal Tyrrell Museum in Alberta, which holds a large collection of bones from tyrannosaurids, close relatives of *T. rex*. From one unidentified species, he found a bone that had holes like Sue's. On microscopic inspection, he found that the holes were spherical and surrounded by distinctive outgrowths—classic signs of gout. While Rothschild is confident that the Tyrrell tyrannosaurid had gout, he can't be so sure about Sue until someone looks at her bones under a microscope as well.

But it's an intriguing hypothesis. In humans gout arises when uric acid, rather than being incorporated into urine and flushed out of the body, diffuses out of the bloodstream and forms crystals that eat into bones and cause arthritislike pain. Gout can be caused by chronic dehydration, kidney failure, or too much red meat. If Sue had gout, Rothschild blames it on her meat-eating habit. Carpenter, on the other hand, suspects her hard, scrappy life. "Sue had a lot of partially healed injuries; there are tooth marks in her face, and broken bones from wounds," he says. "Being ill from these injuries, her kidneys probably shut down."

—Lybi Ma

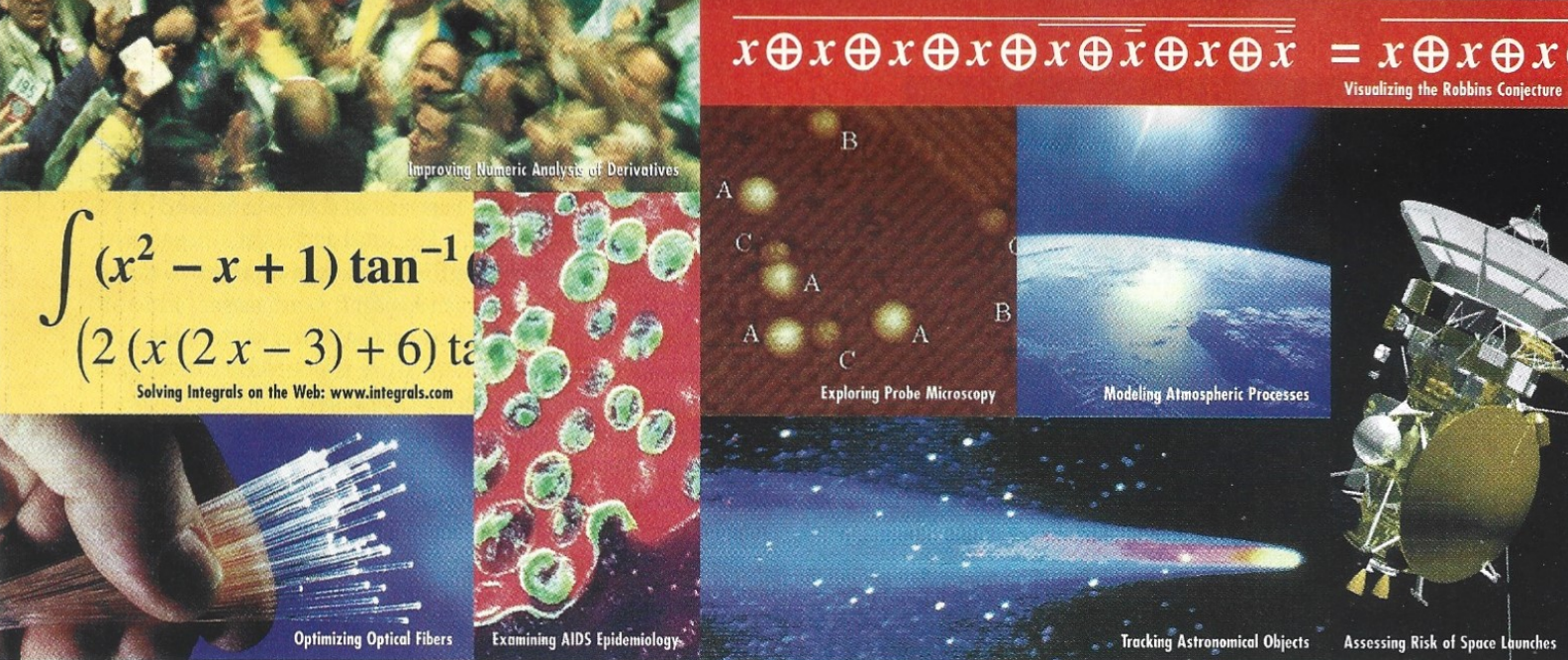
THEROPOD IN PROGRESS One day in October 1995 paleontologist Philippe Taquet had visitors in his lab at the National Museum of Natural History in Paris. Horacio and Isabel Mateus, amateur fossil hunters, came in with a set of tiny bones. They had been walking with their daughter, Marta, along a seaside cliff northwest of Lisbon when Marta came across what looked like black pottery shards. The Mateuses recognized them as fossilized eggshells and soon found bones nearby. Taquet realized they were no ordinary bones. "I saw immediately they were very small bones of dinosaurs, so I rushed to Portugal," he says.

There he joined a group of Portuguese paleontologists who had also seen the fossils found by the Mateus family. "In the first block of 34 eggs there was one egg, crushed open," says Taquet. "We could see the embryo inside perfectly. There were some fragments of vertebrae attached to the inside of the eggshell. This proved it was an embryo, not a baby. This was absolutely splendid." Last June, Taquet and the Portuguese researchers made clear just how splendid Marta's discovery was: they announced she had found the oldest embryo of a carnivorous dinosaur, or theropod. It dates back 145 million years.

Although dinosaur eggs have been found at about 200 sites worldwide, major deposits are few, and embryos are rarer still—this is the first to be found in Europe. Embryos are particularly precious because they can help tie dinosaur eggs to specific dinos and even show how the animals grew. The Portuguese embryo, which resembles an *Allosaurus* from North America, would have been only 10 inches long had it hatched, says Taquet, but up to 30 feet long as an adult.

Perhaps more surprising is that there were three types of dinosaur eggs in clutches at the site, suggesting that it might have been a nursery for different species of dinosaur. This reminds Taquet of birds, which often nest together—and which are thought to be descended from theropods.

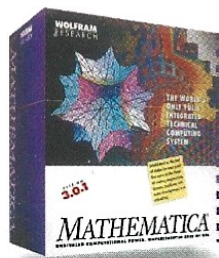
—Ann Gibbons



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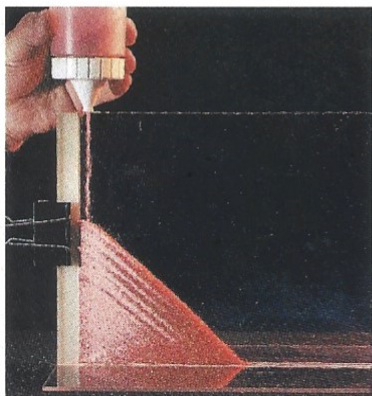
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Simple as Sand

MOST REPORTS in scientific journals describe discoveries that the average person has to take on faith. The research demands expensive equipment, specialized expertise, and years of work. But in March physicists published a surprising finding—an explanation for how sand arranges itself in layers on its way to becoming sandstone—that would cost only a few dollars and take only a few



hours to replicate.

"Go to a pet store and buy some nice sand," instructs Eugene Stanley of Boston University, describing the experiment done by his graduate student Hernán Makse. "Then go to the supermarket and get some colored sugar. Take roughly equal parts of each and shake them together." Next proceed to your local hardware megastore for two nine-inch squares of Plexiglas and from them build a tall, thin container like those used for ant farms. You can use a few pennies as spacers and clamp the sheets of Plexiglas together with alligator clips. Tape off three sides, leaving only the top open, and you're ready to go.

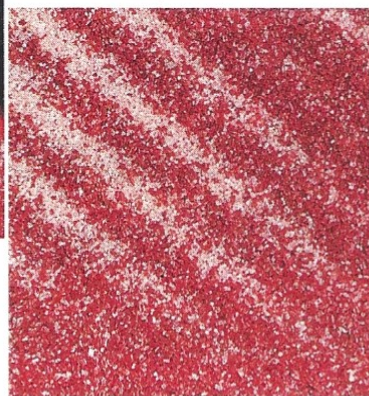


Here's how it works: As the mixture is poured into a heap, it mounds higher and higher. Every so often the mound reaches a critical angle, at which point the grains avalanche down the sides. As they reach the bottom of the heap, they form a little kink. The smaller, smoother grains of sand stop short at the bottom of the kink, while the bigger, rougher grains of sugar go just a bit farther, riding over the sand. As more grains tumble down the heap, the kink rides upward, forming two layers as it goes. Each succeeding avalanche contributes another pair of layers.

Stanley and Makse believe this observation explains how sand grains of different sizes and textures form layers in natural sandstone. But the phenomenon had never been demonstrated until Makse did it for his Ph.D thesis. "No one had done such an idealized version of the experiment," Stanley

says. Perhaps in this era of multimillion-dollar research laboratories it was just too simple.

—Robert Pool



Big rough grains
tumble a bit farther
than smooth small
ones, forming layers.



CLUSTER BOMBS One promising method for creating nuclear fusion is to zap pellets of hydrogen fuel with lasers. To achieve temperatures and pressures high enough to force the hydrogen to fuse into helium, however, scientists have had to build big lasers at considerable expense. Last March a group of physicists at Imperial College in London announced a way to do fusion research with a laser small enough to fit on a tabletop. The trick was to take advantage of the peculiar physics of atomic clusters.

Whereas big laser-fusion devices work by forming a tightly compressed plasma of about a hundred million trillion highly energetic hydrogen atoms, Todd Ditmire and his colleagues squirted an extremely fine mist of xenon into a vacuum chamber, where the xenon atoms hung in clusters—microscopic droplets—of about 2,500 atoms each. Then the researchers fired a sharply focused laser beam into the mist for less than a trillionth of a second. Any clusters that crossed the beam were shredded into highly en-

ergized ions and electrons. When Ditmire measured the speed of the shrapnel-like particles and thus their temperature, he found that they had reached over 940 million degrees Fahrenheit—more than 30 times hotter than the core of the sun. "We expected to see high-energy ions," Ditmire says, "but we certainly didn't expect them to be that high."

How can a small laser unleash so much energy? Since the beam is tightly focused, it packs enough energy into a small enough area to trigger some fancy physics inside the xenon clusters. "The intense laser comes in and rips all the electrons off this ball of atoms so that there's a cloud of electrons within the ball," Ditmire says. As the cloud heats, it swells until it gets to a critical size at which the cloud begins to resonate. "The cloud sloshes back and forth around the xenon ions, and when it's in resonance with the frequency of the laser, you can put a lot of energy into the cloud of electrons." These energized electrons then bash the xenon ions until they themselves are superheated.

—Jeffrey Winters

Score One (More) for the Spooks

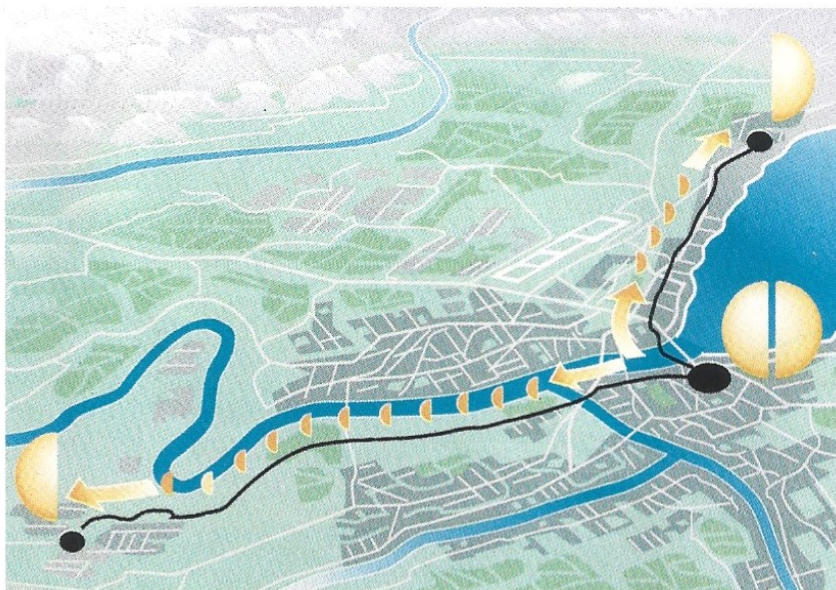
EINSTEIN WOULD NOT have been amused. Not only did researchers demonstrate last May a phenomenon that the Great One once disparaged as “spooky action at a distance,” but they proved it happens even at great distances. Worse, they performed the experiment in Switzerland, not far from the patent office where Einstein worked in 1905—the year he explained the quantum nature of light, which laid the foundation for quantum mechanics, which he later found so maddeningly spooky.

The spooky action in question involves a voodoo-like link between two particles such that a measurement carried out on one has an instantaneous effect on the other, though it be far away—nearly seven miles away, in the experiment done by physicist Nicolas Gisin’s team at the University of Geneva. Gisin and his colleagues borrowed fiber-optic phone lines running from Geneva to two nearby villages. In Geneva, they shone photons into a potassium-niobate crystal, which split each photon into a pair of less energetic photons traveling in opposite directions—one north toward Bellevue and the other southwest to Bernex. At these two destinations, nearly seven miles apart, each photon was fed into a detector.

Common sense would suggest that nothing done to the photon in Bellevue could affect the photon in Bernex, or vice versa, but quantum mechanics never had much to do with common sense. For starters, the uncertainty principle says that Gisin cannot simultaneously know both the energy of a photon and the time it left the crystal in Geneva, at least not precisely. Furthermore, quantum mechanics insists that the photons don’t have precise properties until they are

measured. To show what he saw as the absurdity of the claim, Einstein proposed a simple thought experiment in 1935, and this became the basis for Gisin’s complicated real one.

Einstein believed that the uncertainty principle was just a measurement problem, not a reality problem. His idea, in terms of the Geneva experiment, was that you could learn the energy of one



Reach out and touch: Split photons did it from opposite ends of Geneva, thanks to quantum mechanics.

photon by measuring the energy of the other one far away; by the same token, you could learn a photon’s arrival time by measuring that of its distant counterpart. After all, the two photons had to leave Geneva at the same time, and although their energies might not be equal, they have to add up to the energy of the parent photon. Assuming that these measurements could be made, and that they added up in this commonsense way, Einstein would be correct, and reality would be independent of measurement. Or you’d be forced to argue that the Bellevue measurement instantaneously and spookily changes the reality of the photon at Bernex, which to Einstein was an absurd suggestion.

The mind game itself was proof

enough for Einstein, but in 1964 physicist John Bell turned it into a testable hypothesis. He came up with an equation, called Bell’s inequality, that boiled the question down to a set of measurements of many photons hitting detectors. If energy and arrival time were absolute values, as Einstein believed, then these measurements would be true to Bell’s inequality. If, on the other hand, quantum mechanics was valid after all, and the precise energy and arrival time of a photon did not exist until they were measured, the measurements would violate Bell’s inequality.

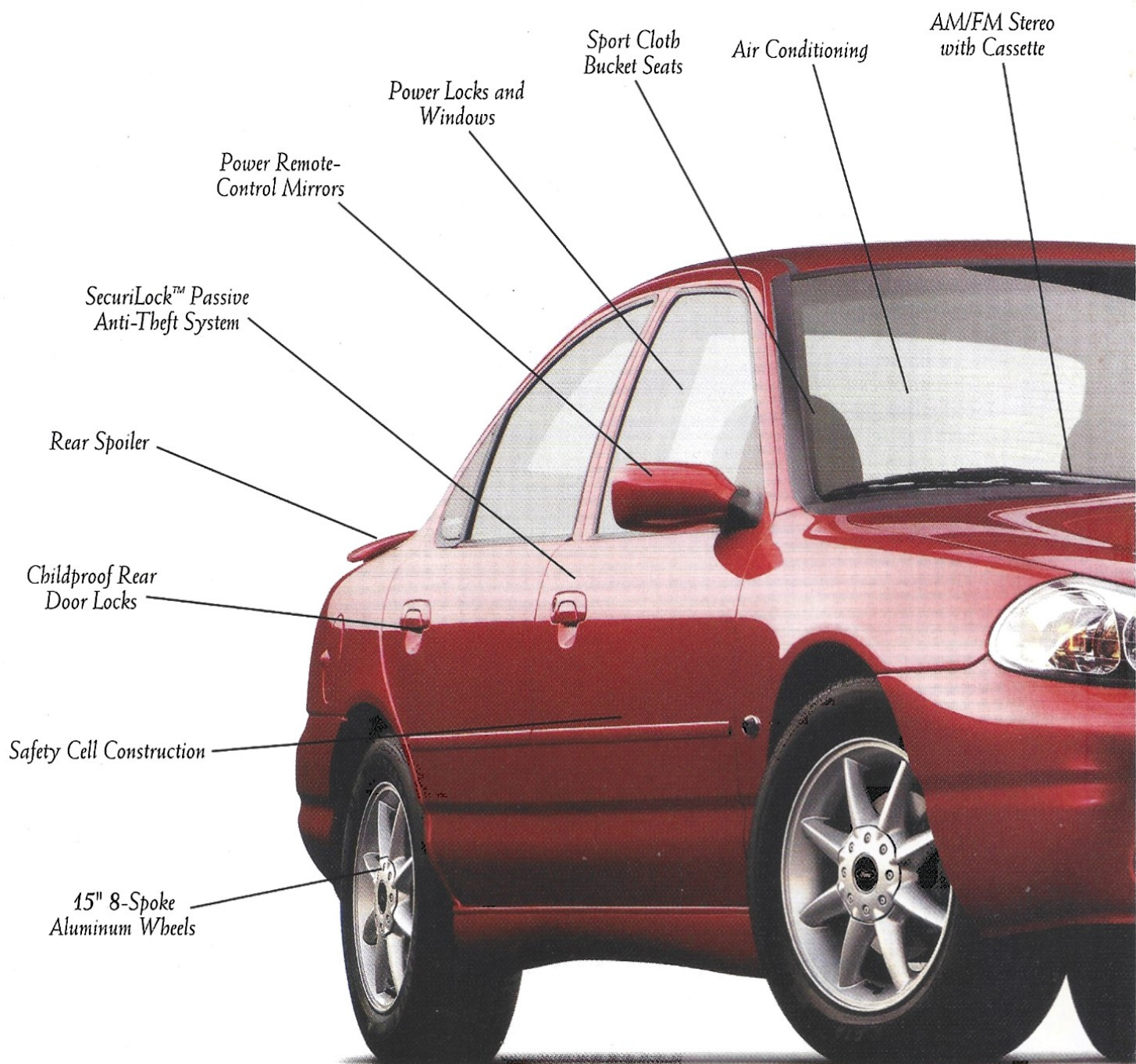
In Gisin’s experiment, alas, Einstein and common sense were the losers. It’s as if he had flipped a coin at Bellevue, Gisin says, while his colleague had flipped one at Bernex, and each time he grabbed his coin out of the air and saw it was heads up, his colleague’s coin had simultaneously stopped spinning and landed heads up as well. And this happened thousands of times in a row. “It is a very strange prediction,” Gisin says, “and because it is so bizarre, it deserved to be tested.”

In fact, it had already been tested many times, most notably in 1981 when physicist Alain Aspect from the University of Paris first dazzled his peers by demonstrating the phenomenon. But Aspect separated his photons by only a few meters, and since then some physicists who share Einstein’s reluctance to abandon common sense had speculated that the spooky effect might decline with distance. “We have now done it in the lab, and we have done it at 10 kilometers, and we found no significant differences,” Gisin says. Common sense, at least in the quantum world, would seem to be a dead horse—but Gisin is planning one more crack at the corpse. He wants to set up a test at an even farther distance—perhaps the 60 miles that separate Geneva and Bern, the site of the patent office where Einstein worked. He even knows when he wants to do it: in 2005, the centennial of Einstein’s pioneering paper.

—Robert Pool

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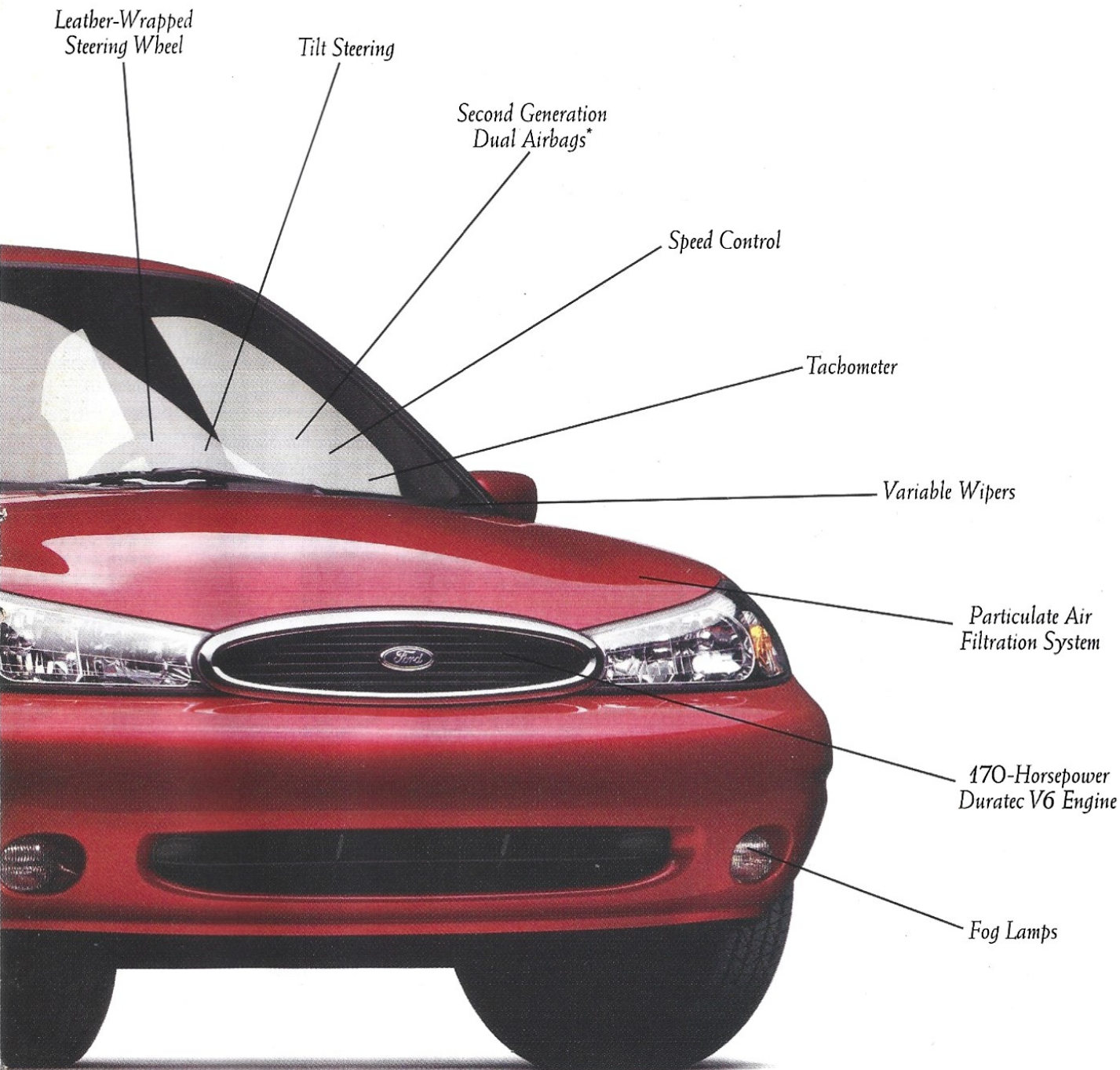


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CREUTZFELDT-JAKOB disease comes in two forms, one old and one new, both terrible and both rare. In both forms the victim suffers microscopic spongy holes in the brain; in both forms the holes are thought to be caused by prions, proteins that sit on the surface of brain cells and turn deadly only when they are—literally—bent out of shape. In the first form of the disease, which strikes late in life, the flaw in the prion is often genetic. But “new variant” CJD, which has killed at least 19 people in Britain in the past three years—all relatively young—is different: it’s thought to be transmissible. Its victims contracted the illness, according to the prevailing theory, by eating prion-laced beef from “mad,” spongy-brained cows—cows with bovine spongiform encephalopathy, or BSE. That theory, when it was proposed in 1996, set off a panic that led other European nations to ban imported British beef and Britain to slaughter and incinerate over 37,000 head of cattle. In the fall two research groups reported re-sounding evidence that the theory is true.

The first report came from pathologist Moira Bruce of the Institute for Animal Health in Edinburgh. She took brain matter from mad cows, new-variant CJD victims, and conventional CJD victims and injected it into the brains of lab mice. She found that BSE and new-variant CJD produced the same pattern of holes in the brains of the mice, as well as similar symptoms of the fatal disease—nervousness, lethargy, and hunched posture. The mice injected with conventional CJD, however, remained healthy.

The second report, by John Collinge of Imperial College School of Medicine at St. Mary’s in London, brought the evidence one step closer to humans. Collinge also injected mashed-up brains from BSE-infected cattle and new-variant CJD victims into the brains of mice—but in his case the mice had been genetically engineered to carry the human version of the

prion protein. After waiting almost two years, he found that both groups not only developed similar symptoms but harbored the same misshapen prion protein.

Neither piece of research proves that the young CJD patients got their disease from eating infected beef—mice are different from humans, and eating beef is different from having ground-up cow brains injected into yours. But the research “shows that you cannot distinguish between BSE and variant CJD—they’re the same thing,” says virologist John Pattison of University College London, who chairs the British government’s Advisory Committee on Spongiform Encephalopathies. “It doesn’t tell you precisely what the nature of that link is, although we do think that the most likely is exposure to beef products.”

British cows, in turn, most likely got

their disease from exposure to sheep products in their feed—the ground-up brains of sheep infected with scrapie, the ovine spongiform encephalopathy. Still, no one has managed to isolate the disease-causing agent from any animal and show that it alone—and not ground-up brain—will cause disease. The most widely held theory is that the agent is none other than a misfolded prion itself. The idea is that an abnormal prion ingested in food travels to the brain, where it somehow subverts the victim’s normal prion proteins, prompting them to flip their folds into the abnormal shape. Neurons die, holes form in the brain, and the transmissible prion propagates itself—all without the aid of genes, DNA, or RNA, for a prion is only a protein.

It is a revolutionary theory, with much evidence to support it but no proof, and many vocal critics, who think an exceptionally elusive virus will be found as the real cause of the spongiform diseases. Thus it came as a general surprise in October when the chief proponent of the prion theory, Stanley Prusiner of the University of California at San Francisco, received the Nobel Prize for, as the



In 1996, fears of mad cow disease prompted the slaughter of 37,000 head of British cattle.

WHERE'S THE BEEF? Twenty-five million pounds of hamburger is a whopping amount of meat. Picture a quarter-pound patty and multiply the image by 100 million. Or picture 50,000 cattle on the hoof. That's a lot of cow, and it gives you an idea of the scope of the recall grimly undertaken by Hudson Foods—under heavy duress from the U.S. Department of Agriculture—last August in the wake of cases involving a harmful strain of *E. coli* (photo).

All together, 15 nonfatal but nasty cases of poisoning by *E. coli* O157:H7 were reported from June to August, all in Colorado. The problem was linked to hamburger produced in June in a Nebraska plant owned by Hudson Foods. In the fallout from the recall, Hudson lost its largest hamburger buyer, Burger King, sold off the Nebraska meat plant, and was ultimately bought by Tyson Foods, the poultry producer.

Why did the recall have to be so huge? The most likely source of the toxic bacteria was one of the ten slaughterhouses that supplied the Hudson plant—and unfortunately, Hudson routinely mixed ground beef from many suppliers into the same processing batch, and even from one day's batch into the next. It isn't clear whether this practice violated meat safety regulations. What is clear, though, was that Hud-

son couldn't produce records showing when the contamination had stopped. Hence the 25-million-pound recall.

Only 8 million pounds of meat was actually recovered. Most of the remaining 17 million pounds "was probably eaten or thrown away," says Becky Triplett, a Hudson spokesperson. Since no other illnesses linked to the Hudson recall were reported, most of the hamburger consumed was either not tainted, or scarcely contaminated, or cooked hot enough (160 degrees Fahrenheit) to kill the bacteria.

The recovered meat was put into two refrigerated warehouses in Arkansas while the investigation continued—and while Hudson tried to figure out what to do with it. One solution: Thoroughly cook the meat to debug it and use it to top foods like pizza and tacos. That was reasonable enough from a scientific standpoint but not from a public relations perspective. Reports in September that Hudson might even consider this option—TAINTED BEEF MAY BE FOR DINNER screamed one headline—were instantly denied by the company. In theory, bombarding the beef with radiation could have made it safe, but meat irradiation—another tough sell to some sectors of the public—has yet to be approved by the Food and Drug Administration.

Rendering is the recalled beef's most likely fate. Usually the process entails cooking meat at 272 degrees to separate the fats for potential use in soaps and cosmetics and to salvage the protein for animal feed. According to Hudson, however, its rendering practices convert all the material to animal and pet feed. Alternatively, the beef could simply be treated as garbage—incinerated or dumped into a landfill. As of early November the decision hadn't been made.

Ironically, the USDA recently launched a "gleaning" initiative to recover leftover food from farms, restaurants, and food suppliers. The aim is to feed the "nearly 12 million Americans" who "may face food insecurity this year," as Dan Glickman, the secretary of agriculture, wrote in a letter to the *New York Times*. That letter was dated September 28, about a month after Glickman ordered the most gargantuan food recall in history. Even within the USDA's own ranks, some people have thought the politically unthinkable. "From a humanitarian point of view," said one scientist, "it's too bad we couldn't cook or irradiate the beef and send it to people who need it."

—Patricia Gadsby

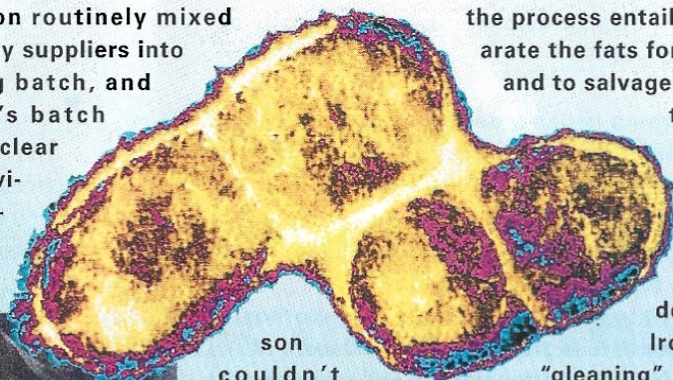
Karolinska Institute put it, "his discovery of prions—a new biological principle of infection." It is rare for the Swedish prize givers to be so cutting-edge, and also rare for them to give the \$1 million medicine prize to just one researcher.

No cases of mad cow disease have been reported in the United States yet, and the incidence of CJD here remained stable from 1979 to 1995, at about one case per one million people a year. Nonetheless, a recent cluster of five CJD cases in Kentucky, reported in August by neurologist Joseph Berger of the University of Kentucky in Lexington, is providing cause for concern. These five peo-

ple had a dietary choice in common: they ate squirrel brains. Thirty-five million squirrels are hunted and killed each year throughout the United States, explains Berger, but in Kentucky "one of the most common methods is to scramble the brains with eggs. The other is to include them in a stew called burgoo, where everything's put in—vegetables and all sorts of rodent parts."

So far, the link between CJD and squirrel brains is tentative—there is no evidence that squirrels even get a spongiform disease. Berger is gathering squirrels from hunters in Kentucky to find out.

—Josie Glausiusz



Tobacco Row

THIS WAS A DIFFICULT year for the tobacco industry. Not only did it agree to what some hailed as a landmark settlement designed to cut smoking rates and bring nicotine under tighter federal regulation, but top tobacco executives admitted in public that smoking was harmful and habit-forming. Among them was Steven Goldstone, chairman of RJR Nabisco, owner of R. J. Reynolds Tobacco Company, who in August was reported to have said, "I have always believed that smoking plays a part in causing lung cancer. What that role is, I don't know, but I do believe it." His remarks occurred in Florida in connection

with one of a wave of tobacco-related lawsuits. At least 40 state attorneys general have sued the industry—and most joined the settlement negotiations—for money to treat tobacco-related disease.

Adding to the industry's problems, then, were new revelations about just how deadly smoking can be—to non-smokers and children. A ten-year, carefully controlled investigation whose results were reported this past year found that women who are constantly exposed to secondhand smoke, at work or at home, are almost twice as likely as others to have a heart attack. And even women who are only occasionally ex-



ROACHES CAUSE ASTHMA Asthma is like a deadly sensitivity to life. Anything from dust to passing clouds to stress induces the response that constricts the asthmatic's airways, leaving the victim with a frightening sensation of drowning in air. It is a chronic ailment brought on by a barely understood concoction of genetic, psychological, and environmental factors—including cockroaches, according to a study released last May.

The incidence of asthma is especially high in poor inner-city neighborhoods. Looking for an explanation for that pattern, allergist David Rosenstreich of the Albert Einstein College of Medicine in New York City and his colleagues spent a year studying 1,500 asthmatic ghetto children in eight different cities. The researchers assessed the kids' sensitivity to 14 common allergens and in nearly half the cases actually measured the levels of cat dander, dust-mite droppings, and cockroach proteins in the homes. They also evaluated the mental health of the mothers—when it's bad, they found, the asthma of the child is more likely to be severe. Secondhand smoke, stress, and air pollution also turned out to be contributing factors.

But in the end the kids with the worst cases of asthma—who suffered more frequent and acute attacks—were those with the most sensitivity and ex-

posure to cockroaches. "They had three times as many hospitalizations as other asthmatic children," says Rosenstreich. "They had twice as many emergency visits, missed school more often, and woke up more often." High exposure to cockroaches also seems to boost a child's risk of developing asthma in the first place, by creating the allergy that eventually leads to the disease.

Fear of crime exacerbates the problem: parents who keep their children indoors inadvertently expose them to higher levels of cockroach allergens. Yet while it is not in the parents' power to control crime or air pollution, or even stress, says Rosenstreich, they may be able to take preventive measures and control the number of cockroaches. "We feel that people should make every effort to clean up their indoor environment and make it allergen-proof, especially the bedroom," he says. "That will help kids with asthma, even if it doesn't cure it. It's a safe and simple thing to do."

—Unmesh Kher

posed experience a 58 percent increase in risk, according to the study's lead author, epidemiologist Ichiro Kawachi of the Harvard School of Public Health.

Another alarming report hinted that smoking-related damage may occur even before birth. In a paper published in the February issue of the *Journal of the National Cancer Institute*, researchers led by epidemiologist Bu-Tian Ji of Columbia found that children of men who smoked for five years before a child's conception were nearly three times more likely to develop leukemia and more than four times more likely to develop lymphoma. The researchers suspect the problem could be caused by smoking-related genetic damage to the fathers' sperm.

Concern for children's health was a driving force behind the settlement negotiations. One stated goal is a ban on advertising aimed at kids; others include cutting the amount of nicotine in tobacco and creating antismoking campaigns. The settlement is currently held up in Congress. Meanwhile, it remains to be seen whether the rising chorus of blame will help drive people—especially children—away from tobacco. The appeal of the noxious leaf remains strong and it manifests itself in surprising ways—the cigar fad being one. A 1997 survey found that more than a quarter of all American high school students smoked at least one cigar this past year. —Catherine Dold



Hepatitis B infects more
than 40 million

Global Tuberculosis Epidemic
Approaches 9 Million

RESURGENCE
OF MALARIA REPORTED

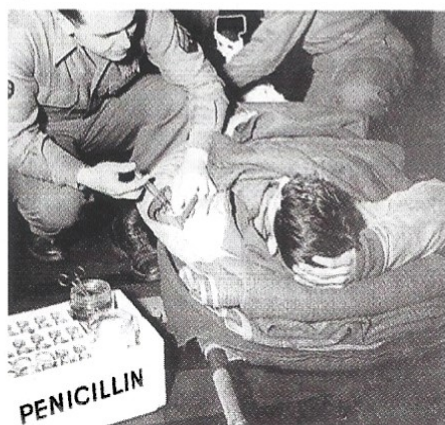
There is only one
way to **prevent** the next

EPIDEMIC.

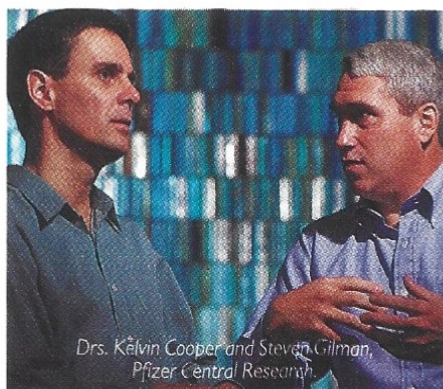
For more than 3 million years, the human race battled nonstop against microbes, or, as most of us know them, germs. And for millennia, microbes won. Waves of plague, typhus, influenza and other infectious diseases left death and suffering in their wake. For most of human existence, life expectancy was short and child mortality high.

Finally, just 200 years ago, humankind scored its first victory when Dr. Edward Jenner successfully immunized 8-year-old farm boy James Phipps against smallpox. Another 132 years passed before the next real advance—the discovery of penicillin in 1928 by Dr. Alexander Fleming.

Fleming's discovery marked the dawn of modern medicine. But because it was impossible to make



We will win
battles. But the war
against microbes
will never end.



penicillin in any significant quantity, it wasn't widely available until 1944, when a company called Pfizer pioneered its mass production, just in time to save the lives of thousands of U.S. servicemen in WW II.

Over the next two decades, the

dramatic success of penicillin and of subsequent vaccines and antibiotics led us to believe we could control or cure anything. After all, we'd seen polio virtually vanquished and had neutralized the threat of measles, whooping cough and diseases such as influenza and pneumonia that were once killers. By the late 1960's, when then U.S. Surgeon General William Stewart announced that we could "close the book" on infectious disease, he echoed a sentiment widely held throughout the country.

He could not have been more wrong. Today we face AIDS, Ebola, Lyme disease—diseases unrecognized a generation ago. And some infectious diseases, including tuberculosis and the more common bacterial pneumonia,

Pfizer's development of a method to mass-produce penicillin saved the lives of thousands of U.S. servicemen in WW II.

541

Bubonic plague kills
10,000 daily

1590

Microscope
invented

1676

Microorganisms
seen for first time

1683

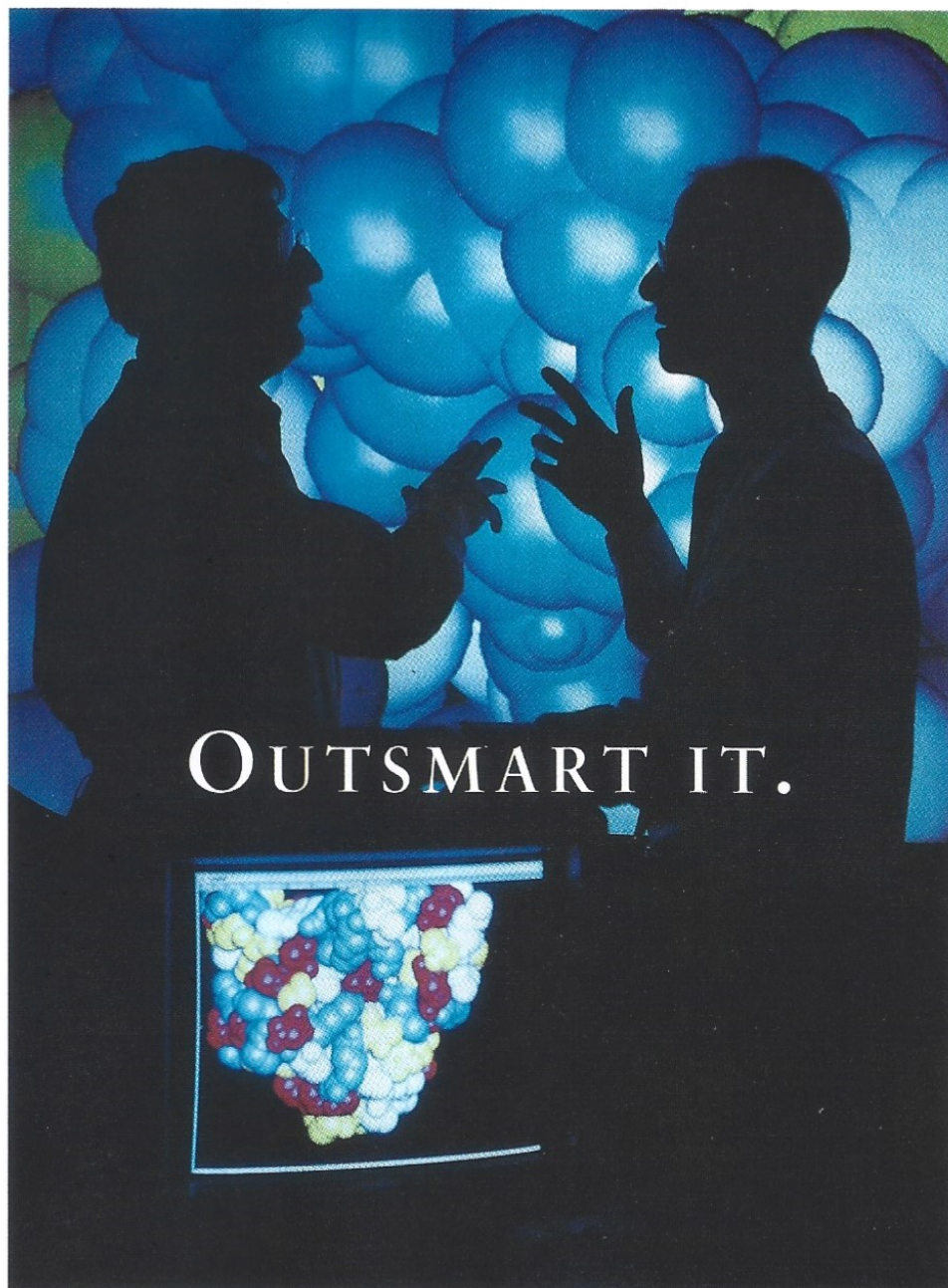
First bacteria
discovered

1796

Edward Jenner
discovers smallpox
inoculation

1862

Pasteur links
germs to specific
diseases for first
time



OUTSMART IT.

all too frequently mutate to form resistance to traditional antibiotics.

Kelvin Cooper, Ph.D., director of immunology and infectious disease research at Pfizer Inc's Central Research division in Groton, Connecticut, puts the current situation into perspective: "Microbes are the perfect evolutionary mecha-

nisms. The lightning speed with which they can adapt gives them a great advantage in our efforts to control them. A single human generation spans about 20 years, but bacteria produce a new generation every 20 minutes. We can never underestimate their ability to evolve resistant strains."

Despite the Rambo-like survival skills of microbes, Steven C. Gilman, Ph.D., assistant director of Pfizer's immunology and infectious disease effort, is confident. "I don't agree with the apocalyptic view that the plague is once again at our door. But I do believe we must be preemptive. The failure in the 70's and 80's to realize how 'smart' bacteria can be planted the seeds of our current problems."

A decade ago, when many pharmaceutical companies radically cut back or entirely abandoned antibiotic development, Pfizer scientists continued the work that had made the company a renowned leader in anti-infective research.

After the success of penicillin and other medicines, we started to believe we could cure anything.

1865

First surgical disinfectant reduces death rate from 45% to 15%

1892

First virus discovered

1928

Penicillin discovered, but only available in small amounts

1944

First-ever mass-produced penicillin, from Pfizer

1952

Salk discovers polio vaccine

MICROBES

INVISIBLE INVADERS

AMAZING ALLIES

Will Microbes Invade A City Near You?

Be on the lookout for

Microbes: Invisible Invaders... Amazing Allies, a new traveling museum exhibition sponsored by Pfizer. Experience the good, the bad and the funny-looking when the world of microbes comes to life at this kid-friendly, hands-on learning environment.

Exhibit will run through Fall 2002. For more information, please visit the Microbes Web page at www.pfizer.com/rd/microbes.

Ontario Science Centre
Toronto, Ontario, Canada

Sept. 27, 1997 through
Jan. 4, 1998

Liberty Science Center
Jersey City, New Jersey

Jan. 24, 1998 through
May 3, 1998

Natural History Museum
of Los Angeles County
Los Angeles, California

May 23, 1998 through
Sept. 7, 1998

California Academy of
Sciences
San Francisco, CA

Oct. 3, 1998 through
January 10, 1999

"Our programs are science driven," says Gilman. "While some companies thought the battle had been won, Pfizer listened to its scientists, who continued to be concerned about antibiotic resistance and believed our problems were far from over."

Today Pfizer's scientists are

exploring novel strategies to hold bugs at bay. One of the most promising involves the use of new discoveries about genes to craft the next generation of cures.

With a California company, Microcide, Pfizer scientists are designing an antibiotic to target the genes essential to microbes'

We must always remain dedicated to research. It's the only way to stay one step ahead.

survival. "This started with a project to find all the essential genes bacteria need to live," explains Kelvin Cooper. "They've been found. Now we're designing drugs to attack them." Pfizer and Millennium Pharmaceuticals have formed a similar partnership, which is using genetic science to search for better antifungal medications.

Hopefully, after further research and development, these new forms of treatment will be available and humanity once again will have scored a major victory against infection.

But Steve Gilman adds a final word of caution: "We must always remain dedicated to research. It's the only way to stay one step ahead. We will win battles. But the war against harmful microbes will never end."

1965

First synthetic
antibiotic

1979

World Health
Organization
proclaims the end of
smallpox

1996

Signs of microbial
life found on Mars



We're part of the cure.

www.pfizer.com
AOL keyword: Pfizer

Backward Blood

FOR THE HALF MILLION Americans who suffer a stroke each year, the odds of recovery are grim. Only about one in five recovers completely, and one out of three dies. But last February, John Frazee, a neurosurgeon at the UCLA Medical Center, introduced an experimental procedure that may one day improve those odds. Most strokes occur when a clot in a cerebral artery cuts blood flow to the brain, depriving neurons of oxygen and ultimately killing them. Frazee has found a way to use veins to deliver oxygen-rich blood to the affected neurons—in effect reversing normal blood flow in a part of the brain.

The method, which has been tested on baboons, is called retrograde transvenous neuroperfusion. Frazee describes it simply as a “backdoor approach” to treating stroke. “The front door to the brain is blocked by a clot,” he says. “This is another way in.”

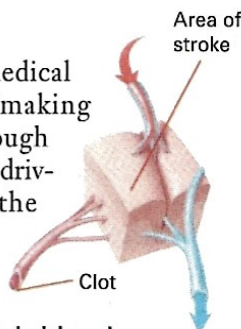
With the patient sedated but not asleep, blood from the large femoral artery in the groin is drawn through a mechanical pump into catheters inserted into the jugular veins on either side of the neck. Guided by X-rays, Frazee maneuvers the thin tubes toward a pair of veins in the back of the head. Tiny balloons near the tips of the catheters are then inflated to block normal blood flow and permit oxygen-rich arterial blood to be pumped backward through the veins toward the affected artery. This blood is then drained normally through other veins leading back to the heart.

The treatment offers patients precious time, Frazee explains. Neuroperfusion can be started in 30 minutes and the pump can keep blood circulating backward for several hours. During that time clots may dissolve naturally, or doctors can begin emergency measures—such as administering a clot-busting drug or performing surgery.

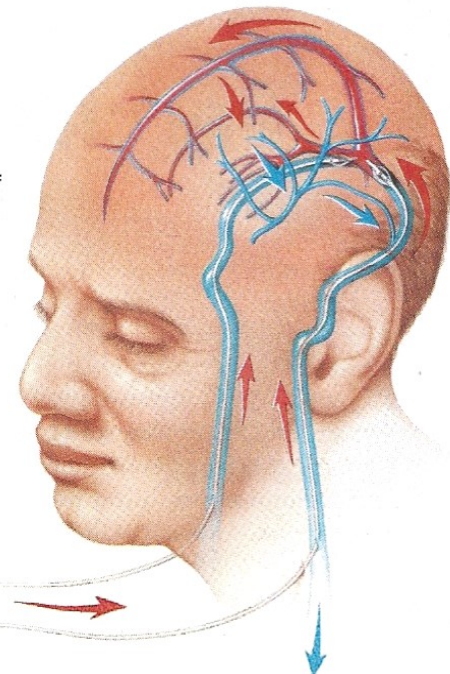
Last February, Frazee announced the results for his first six patients; he has since performed the procedure on two others. Three have fully recovered, three showed some improvement, and two remained unchanged. Larger trials will soon begin in several hospitals. But even with very good results, it will take time for such an approach to gain acceptance.

“Intuitively, for most medical people,” says Frazee, “making blood go backward through the venous system is like driving the wrong way on the L.A. freeway.”

—Jeff Goldberg



Tubes feed oxygen-rich blood (red) through veins to the area of the stroke. Other veins (blue) carry the blood back to the heart.



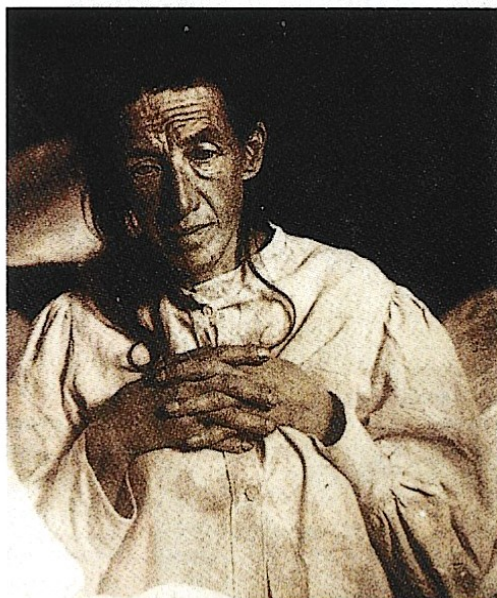
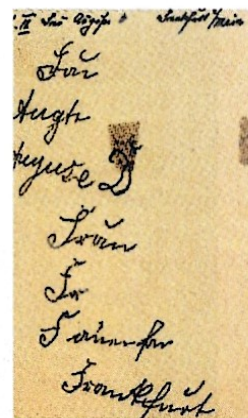
THE MISSING FILE OF AUGUSTE D. The first line reads: “She sits on the bed with a helpless expression. What is your name? Auguste. Last name? Auguste. What is your husband’s name? Auguste, I think.” The 32 pages of medical records that follow are the oldest medical description of Alzheimer’s disease. Psychiatrist Konrad Maurer and his colleagues at Johann Wolfgang Goethe University in Frankfurt found the file in their hospital’s archive, where it had been missing for nearly 90 years, and published excerpts from it last May in *The Lancet*. The notes, in a cramped, archaic German script, were written by Alois Alzheimer—the physician who first described the disease.

His patient, Auguste D., was a 51-year-old woman who had suffered fits of paranoid jealousy and memory lapses so disturbing that her family finally brought her to a local hospital known as the Castle of the Insane. Over the next four years Alzheimer tracked her condition. Upon her death he examined her brain tissue and found the distinctive lesions that are now hallmarks of the disease.

Today Alzheimer’s afflicts some 4 million Americans. Although it still cannot be cured, or even treated very well, several recent studies hint that some treatments—from estrogen to vitamin E to anti-inflammatory drugs—can reduce either the risk of developing the disorder or its symptoms. And more is being

learned about its distinctive pathology. This past year, for instance, researchers discovered a new kind of lesion in Alzheimer’s patients. A genetic study also pinpointed a mutation that is present in some 60 percent of them—a mutation in the DNA of mitochondria, the energy-producing organelles of the cells.

But nearly a century ago, it was Alois Alzheimer who first described the disease and in so doing became one of the first physicians to offer a biological basis for a psychiatric condition. Finding the file, Maurer says, “is like holding history in your hands.” —Sarah Richardson



Perchance to Die

THE LAST THING Africa needs is another deadly epidemic. Yet alarming reports of sleeping sickness in equatorial Africa reached the Western world this summer. "Whole villages will die," predicts Anne Moore, an investigator for the Centers for Disease Control who visited the current hot spot in southern Sudan. In a preliminary study her team found that close to 20 percent of those tested in the region of Tambura had the lethal parasite *Trypanosoma brucei gambiense* in their blood. In Ezo, a town of 6,000, some 45 percent of those screened tested positive. "In a village near Ezo everyone has apparently died except the few that fled," says Moore.

Sleeping sickness, officially called African trypanosomiasis, was once Africa's biggest public health scourge. It begins with a bite from a tsetse, a fly with a nasty taste for blood. If your fly is carrying the trypanosome pathogen, that bite can transmit the disease. A lousy flu-like feeling sets in as you fight a foe that

multiplies and fakes out your immune system by changing its outer coat. Sooner or later, parasites inflame your brain, causing weird changes in behavior, personality, and sleep. You sink into zombie-like apathy, and eventually lapse into a coma that ends in death. A turn-of-the-century epidemic in the Belgian Congo killed half a million people.

Today, with prompt treatment, the disease is curable. In fact, until recently it was well controlled. So what went wrong? Regional civil war is one problem: people fled into the bush and ran into flies. More important, war chased out Belgian doctors in the late 1980s, and relief organizations like CARE and the International Medical Corps only recently returned.

And then there are problems with the treatments themselves. Melarsoprol attacks the parasite's ability to fend off the body's defenses, but it's toxic and costs roughly \$150 for a weeklong course of treatment. A less toxic drug, DFMO (difluoromethylornithine), works by pre-



Sleeping sickness in Sudan.

venting the parasite from multiplying, but its \$400 price tag is far too high for countries poor in medical resources. That's one reason doctors in Sudan called the CDC: they needed to document the epidemic to raise cash.

But the outbreak in Sudan is only the tip of the iceberg. Tens of thousands are said to be dying each year in the Democratic Republic of the Congo (formerly Zaire). And there's word of flare-ups elsewhere in the tsetse belt. —Patricia Gadsby

FEAR THE PIGS No one knows why the great influenza pandemic of 1918 was the most virulent of all time. A spring outbreak in the American Midwest had by year's end spread to every corner of the globe. It left as many as 40 million people dead—and among them were American soldiers who carried it to Europe on their way to battle in World War I. (Photo shows patients in a U.S. Army field hospital, Luxembourg, 1918.)

One was an Army private who fell victim to the flu at age 21. Though he did not survive, his lung tissue did, encased in paraffin wax and stored at the Armed Forces Institute of Pathology in Washington, D.C. Last March molecular pathologist Jeffery Taubenberger and his colleagues at the institute announced that they had succeeded in get-

ting the first direct look at the 1918 virus. Using the polymerase chain reaction—a method of amplifying tiny pieces of genetic material—they managed to extract flu virus RNA from the soldier's preserved lung.

That genetic fingerprint disproved a major hypothesis about the 1918 pandemic. It had been thought that the virus might have hopped into humans directly from birds. Coincidentally, it has recently been shown that such transmission really can occur: in May an avian virus infected and killed a three-year-old Hong Kong boy. Although the boy's death has alarmed public health officials, it appears to be a freak case, says Taubenberger—and not at all what happened in the 1918 pandemic.

Instead his analysis shows that the 1918 flu strain was more closely related to a pig virus than to an avian virus, although it had a touch of both. Indeed, it supports the theory that pigs—which can be infected by avian and human flu strains as well as by their own—are dangerous "mixing vessels" that give rise to new strains lethal to humans.

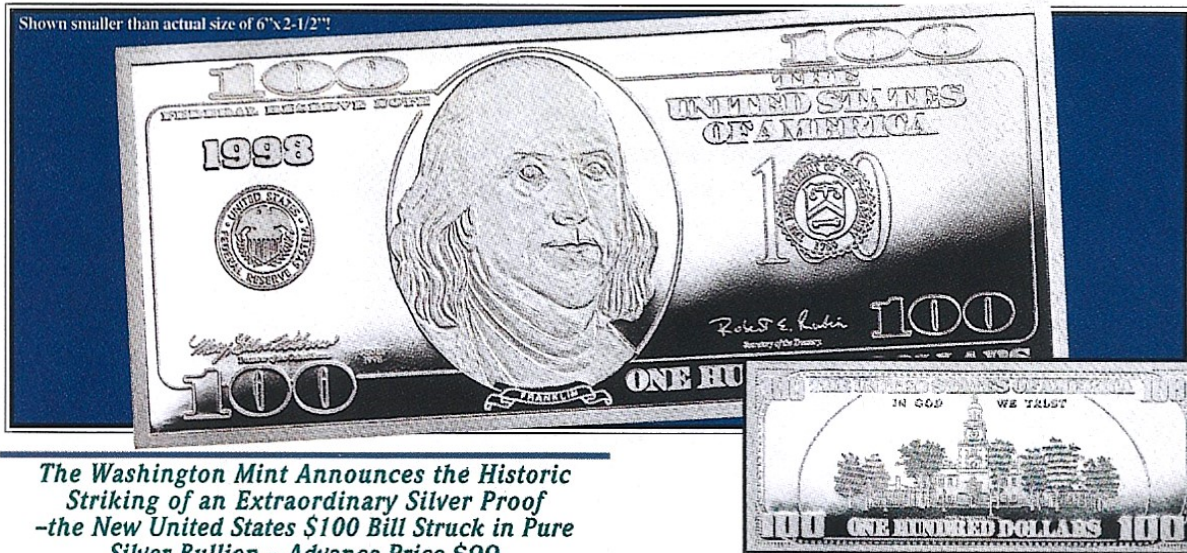
Unfortunately, Taubenberger hasn't yet figured out what made the 1918 strain so deadly, although he is still trying. "If we could learn something about why the virus in 1918 was so lethal," he says, "it would help us predict when an influenza virus with that kind of ability would emerge again. And if a virus arose with those similar features, it could be recognized and a huge effort could be mounted to vaccinate people against it." —Josie Glausiusz



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His Chickens Quail

BY TRANSPLANTING BITS of quail embryos into chicken embryos, Evan Balaban of the Neurosciences Institute in San Diego this past year created chimeras that cheep like chickens but bob their heads like quail. Why? you ask. Balaban wants to know why different species with similar brain architecture behave in markedly different ways, even when the behavior—like birdsong—is at least in part hardwired rather than learned. Quail and chickens have virtually identical brains, but their songs differ. When a young chicken crows, it merely raises its head and squeaks. A quail has more flair: its call is divided into three parts, the last a musical tremolo, and while it sings its head bobs as much as 20 times a second. How did evolution accomplish the change from one to the other? Balaban asks.

He began to study the quail neural tube, the part of the embryo that develops into the nervous system, in the mid-1980s. "I wanted to see," he explains, "if there were any populations of cells I

Why is this chicken acting like a quail? Because it has a bit of quail brain in its head, of course.

could transplant that already knew the difference between chicken and quail." In 1988 Balaban discovered that the midbrain knows the



difference between crowing styles. By transplanting midbrain cells, he could make chickens sing like quail. They still couldn't manage that little warble at the end, however—probably because they still held their heads high and steady.

Last March, Balaban reported how to make chickens bob their heads: just give them a quail's caudal brain stem, a clus-

ter of neurons right above the spinal cord.

Soon, by transplanting both caudal brain stem and midbrain cells, he thinks he will create chickens that can do it all—the three-part quail song with the head-bobbing warble. And that, he believes, is how evolution differentiated the two species—not by attacking, in one fell swoop as it were, a single "higher" brain center that compiles and organizes the impulses of "lower" brain components but by making independent changes to the lower components themselves. "Maybe the higher parts of the brain," Balaban speculates, "are much more similar among different species than we appreciate right now. And what is very different about them are the lower parts."

—Unmesh Kher

Keeping Track of Things

SHOW A BABY A TOY, then cover the toy with a blanket. How does the baby know it's still there? For that matter, how do any of us remember where things are without gazing directly at them? Psychologists call this cognitive feat object permanence, and this year a group at Princeton got a look at part of

the answer, in monkeys at least. They found that some neurons not only encode information about an object's location but can even retain a short-term memory of it.

Neuroscientist Michael Graziano and his colleagues monitored the electrical activity of individual neurons in the pre-

motor cortex, a brain region involved in planning and executing movement. In an earlier experiment they had learned that individual neurons in a particular neighborhood of the premotor cortex respond to both visual and tactile stimuli: they fire rapidly when an object is looming within ten inches or so of a monkey's face and also when it touches the face, even if it is out of sight. "These neurons' overarching job, we think, is to say, 'There is an object on or near this particular part of the body,'" says Graziano.

This past year Graziano and his colleagues showed that those neurons, even



A neuron fires when the facial area it tracks is stimulated.

individual ones, can briefly store information about an object's whereabouts. The researchers put a monkey in the dark, placed a bar within ten inches of the

left side of its face, and illuminated the bar for a split second. As expected, a particular premotor cortex neuron began responding when the bar first came into view—but it continued firing rapidly for five seconds after the bar disappeared in darkness. If during that interval Graziano

turned the monkey's head, putting the bar near the right side of the face, the neuron stopped responding—only to resume its rapid firing when the monkey's face was turned back to the starting point. The neuron was in effect remembering not only the presence but the location of the bar in relation to the face. It was responsible only for the left side.

Humans and monkeys alike also form longer-term memories of familiar terrain. But Graziano's experiments suggest where we get our crucial ability to grab a cup of coffee without looking and without sending it flying across the desk: we owe it to individual neurons in our premotor cortex, which form short-lived maps of particular chunks of nearby space. "When we look around," Graziano says, "we know where objects are located, and we feel that there must be one map in our brain that keeps track of everything. But what's coming out is that there are a lot of subregions and modules keeping track of parts of space. Spatial processing seems to be broken up in a kind of divide-and-conquer method."

—Sarah Richardson

BETTER NOT INHALE Nobody disputes that marijuana is mind-altering. But is it a harmless herb or a step down the slippery slope of drug addiction? Two reports, both published in *Science* in June, throw a sinister light on the funny cigarettes. In these studies of rats, researchers turned up evidence that marijuana produces the same biochemical changes in the brain as heroin, cocaine, or, for that matter, nicotine and alcohol.

A common feature of addictive drugs, explains Italian pharmacologist Gaetano Di Chiara, is that they prompt release of the brain chemical dopamine in the outer layer of the nucleus accumbens, a thimble-size region in the limbic forebrain. This outer layer, he adds, is involved in regulating motivated behavior, such as mating, eating, fighting, and mothering. When Di Chiara and his colleagues at the University of Cagliari gave the active ingredient of marijuana intravenously to rats, they found that it, too, prompted dopamine levels in the nucleus accumbens to rise—just as, say, an injection of heroin would.

Moreover, the researchers found they could prevent either marijuana or heroin from releasing dopamine with a drug that blocked only the heroin receptors on the rats' brain cells. That suggests, says Di Chiara, that marijuana interacts, directly or indirectly, with heroin receptors as well

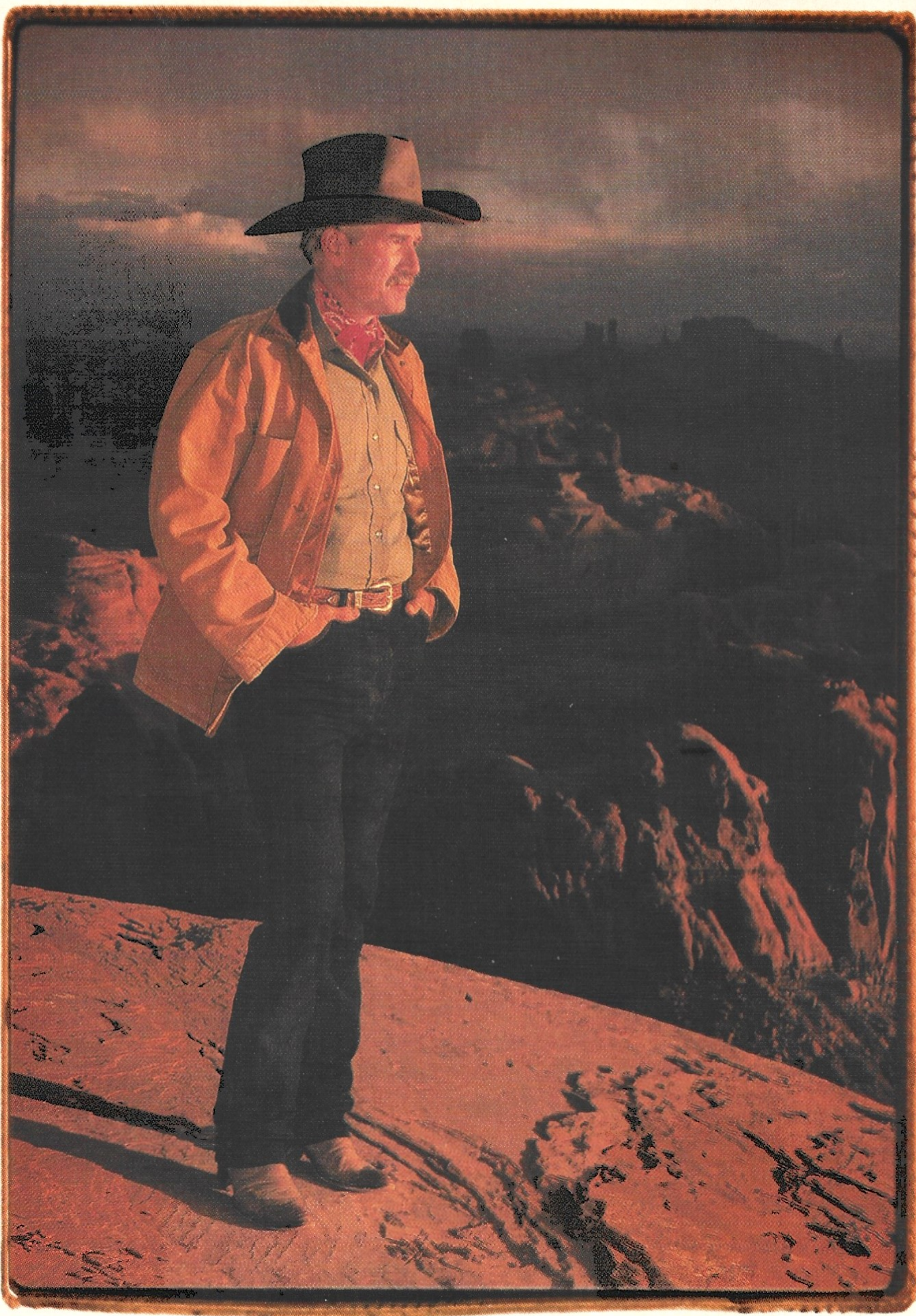
as with the ones that are specific to it, so it could well prime the brain for stronger stuff. Epidemiological studies show frequent marijuana use to be a risk factor for heroin use.

Still, giving up marijuana doesn't produce as strong a withdrawal syndrome as other addictive drugs do—but that may be because the drug is slow to leave the body. In the second study, researchers produced a pot version of cold turkey by giving synthetic marijuana to rats for two weeks, followed by a compound that quickly blocked the marijuana receptors. The team, led by neurobiologist Fernando Rodríguez de Fonseca at Complutense University in Madrid, found that the rats became stressed—they fidgeted and groomed themselves nervously. Meanwhile their amygdala, a brain region that regulates emotional responses, released large amounts of a brain stress hormone. Rats abruptly taken off heroin experience similar effects.

Neither study shows, though, that the two drugs are equally addictive. "It is likely that there is a big difference between intravenous heroin and marijuana," says Di Chiara, "but this is not because the two substances are so different from the point of view of impact on the brain. One possibility is that the difference is just a question of the amount and means of administration."

—Sarah Richardson





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New Harmony on Main Street

SINCE THE 1930S, when a fateful shipment of infected French logs arrived in Cleveland, millions of American elms—the quintessential Main Street shade tree—have withered, yellowed, and

Wholesale nurseries began producing them in early 1997.

Geneticist Alden Townsend of the U.S. Department of Agriculture's National Arboretum lab in Glenn Dale,

Maryland, spent nearly three decades screening tens of thousands of trees for tolerance to the disease, which is caused by a fungus called *Ophiostoma ulmi*. The fungus infiltrates the trees' xylem, or water-transport system, producing countless spores. The cells surrounding the xylem form protrusive growths, and together the protrusions and spores clog up the waterworks and dry out the tree.

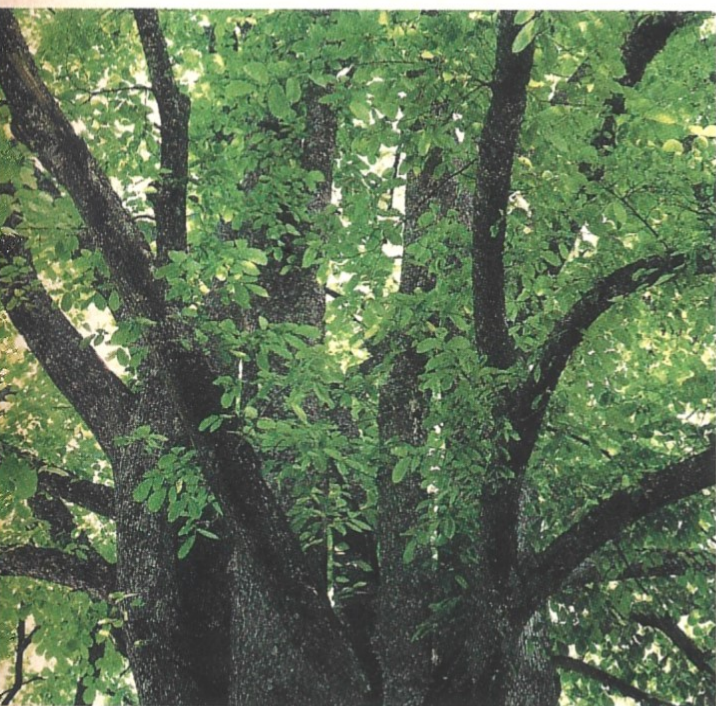
As researchers have done since the 1930s, Townsend combed forests for the healthiest-looking elms, collected cuttings and seeds, and nursed them into trees. "We inoculated thousands of trees with the fungus," he says. "Then the most tolerant were picked, propagated, and



After disease-ridden decades, the American elm may return to its former splendor.

reinoculated. After a series of tests over a number of years, we narrowed our candidates down to the two trees that showed the least amount of dieback."

Townsend isn't sure why the two cultivars—Valley Forge, which one of his predecessors grew from a seed collected in the northern United States, and New Harmony, which Townsend found in an Ohio forest—tough out the fungus better than other elms. "There are all kinds of theories," he says. "One is that these trees produce a chemical in response to the fungus that suppresses sporulation and growth. We do know that when we inoculate these trees, we can still later recover the fungus. That's why we emphasize that they are not immune or resistant to the fungus—they tolerate its presence."



died from Dutch elm disease. But the American elm may yet make a comeback, thanks to the discovery of two new varieties that can withstand the disease.

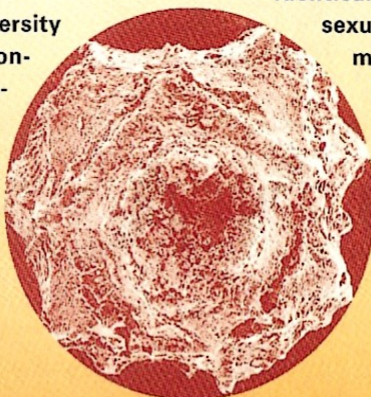
AN ANCIENT CONVENIENCE Cloning may be big news in the animal kingdom, but to plants it's a big yawn. They've been reproducing by cloning since day one. The more recent trend in the vegetable set is sex—in particular, using distinct sperm and egg cells. But a tiny fossil described in *Nature* last January suggests that trend, too, has been around for quite a while.

Paleontologist Raimund Feist of the University of Montpellier II chanced upon the 405-million-year-old fossil in the Montagne Noire mountains in southwestern France. Not a plant man himself, Feist nevertheless recognized the one-millimeter-wide fossil as a possible charophyte—a type of green alga that lives in rivers and lakes and that just happens to be the area of expertise of his wife,

Monique, a paleobotanist at the same university. "He asked me, 'Do you think it might be a charophyte?' And I said, 'Yes! Ooh, amazing,'" she recalls. "And it became evident that it was the oldest bisexual plant yet discovered."

In fact, it is the oldest plant yet found with distinct male and female sex organs—earlier sexual plants exchanged identical gametes—and like modern flowers, it is bisexual in that it carries its male antheridia and female oogonia on the same structure. The fossil charophyte shares a common ancestor with land plants. Botanists have long debated whether the earliest sexually reproducing plants were unisexual, bearing either female or male sex organs, or bisexual. The French fossil offers support for the latter hypothesis.

—Josie Glauisusz



By 2000, the New Harmony and Valley Forge trees now growing in nurseries will be large enough to sell. By then, however, Townsend will have tested

other promising clones—including crosses with the two—and may be ready to release another, even more tolerant tree.
—Kathy A. Svitil

Keep the Aspirin Flying

TIME WAS, only the most spiritually inclined believed that plants cry out when they're in trouble. Last February, though, biochemist Ilya Raskin and his colleagues at Rutgers University published a paper suggesting that they think so, too. The tobacco plants they studied signal their distress not with sound but with a chemical—salicylic acid, or aspirin.

Researchers first found salicylic acid a century ago in willow bark, and many plants seem to produce the chemical. But

with tobacco mosaic virus, which forms dark blisters on leaves and causes them to pucker and yellow. The sick plants produce salicylic acid in large quantities. He and his colleagues found that some of the acid turns into methyl salicylate, a volatile chemical that evaporates from diseased parts of plants. When the researchers pumped air from infected tobacco plants over healthy ones, the healthy plants absorbed the methyl salicylate and turned it back into salicylic acid.



When disease attacks, tobacco plants warn their peers.

it was not until six years ago that Raskin and other researchers discovered that plants use the acid to alert their immune system to start fighting infection. This past year, Raskin found that the aspirin can also take to the air—not only activating an immune response in the plant that produced it but switching on the resistance of nearby plants. This is the first case, says Raskin, of plants communicating to fend off disease. “Plants can’t run away, and they can’t make noises or sounds,” he says. “But they are wonderful chemists.”

Raskin studied tobacco plants infected

That triggered the production of immune-system proteins, making the healthy plants more resistant to the disease. On the other hand, when the researchers removed the methyl salicylate first, the rest of the air caused no increase in the healthy plants’ immunity.

Raskin sees crops one day being treated with aspirin instead of pesticides. In the case of fruits and vegetables, which are still alive long after their harvest, salicylic acid could even help them resist disease while they are being stored. “Instead of spraying toxic chemicals and poisons to kill pathogens,” Raskin says, “this is supplying the plants with a natural substance to boost their own immunity.”

—Fenella Saunders

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TO THE MILLIONS of people glued to their televisions last Fourth of July, the Pathfinder mission to Mars was a resounding success. It gave them expansive views of a rock-strewn, undulating terrain washed billions of years ago by a flood of Noachian proportions, dust-laden pink Martian sunrises, and images—sometimes comical—of the Sojourner rover ambling like an Erector toy from rock to rock. The probe even sent Martian weather reports: there was a deep chill in the summer air and the dust devils were out.

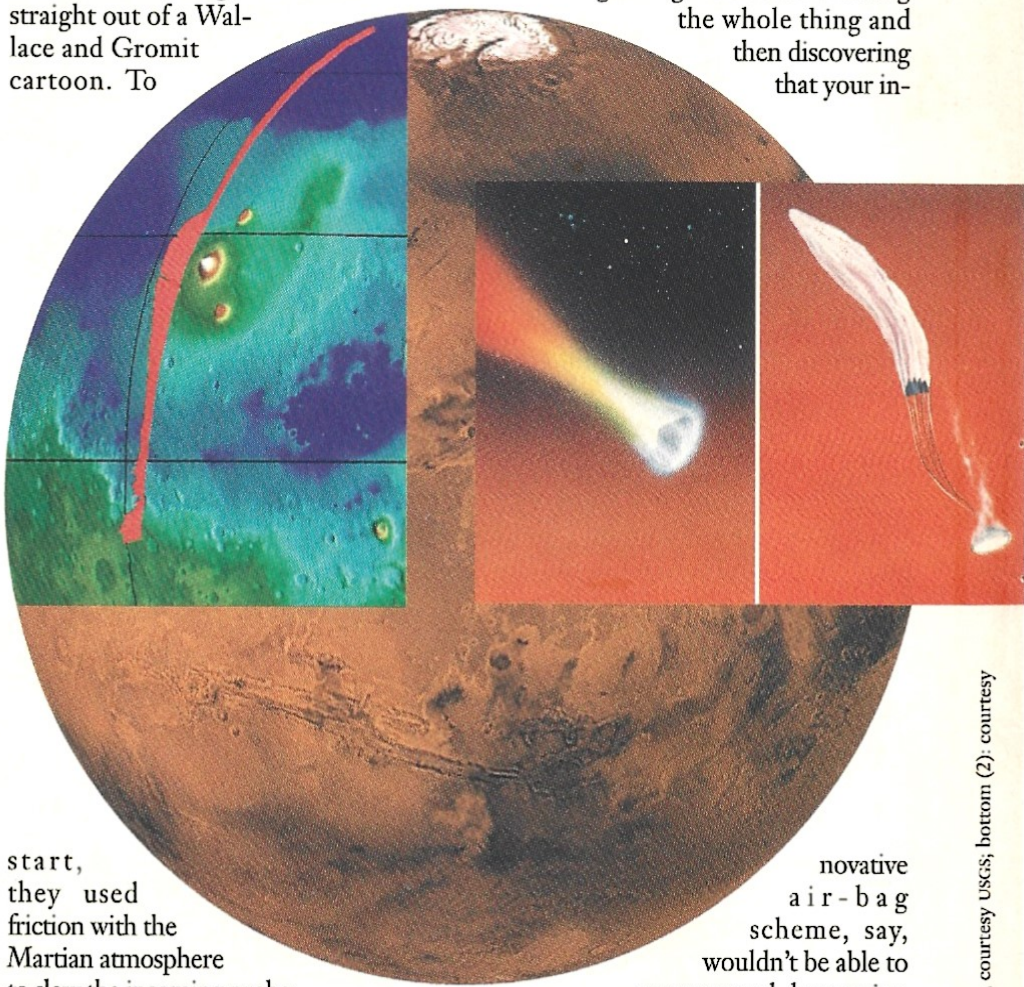
But the most novel achievement of Pathfinder was not the images, as entrancing as they were, nor the data that went with them—it was the engineering. Pathfinder was NASA's first big demonstration of its "cheaper, better, faster" credo. Charged with doing what previous projects had done but at a fraction of the cost, NASA engineers were forced to rethink their notion of how to deliver a probe to the Martian surface. "We had to throw out the book and start over," says Brian Muirhead, flight system manager for the project. "With Pathfinder, we needed to reinvent the entire process of doing a planetary mission."

To save on weight and rocket fuel,

Pathfinder saw Martian dirt and rocks, and even a Martian sunset.



Pathfinder engineers dispensed with the lavish retro-rockets that eased the Viking landers featherlike onto the red dust back in the 1970s. Instead they dreamed up an elaborate landing scheme straight out of a Wallace and Gromit cartoon. To



start, they used friction with the Martian atmosphere to slow the incoming probe from 17,000 to 840 miles per hour, which is slow enough in the thin atmosphere to release a parachute. Then they waited until one second before impact to have *Pathfinder* fire its three small retro-rockets, which brought it to a dead stop

ten stories above the surface. From there the probe cut itself free of its tether and simply dropped to the ground. Encased in a cocoon of air bags, it bounced 15 times before rolling to a stop.

Defying death in such an undignified way required an entirely different engineering process from previous missions. Viking engineers, designing and building what even for the time was a less radical spacecraft, did most of their testing at the end when it was fully assembled. Pathfinder engineers, in contrast, exhaustively tested and retested almost every component of the probe from the beginning—no sense building the whole thing and then discovering that your in-

novative air-bag scheme, say, wouldn't be able to prevent total destruction on impact. Tests of individual parts led to redesigns of those parts, and sometimes to modifications of the probe as a whole. "Testing until it worked every time, you got to a design that doesn't not work," says Pathfinder engineer Rob

Manning of the Jet Propulsion Laboratory. "Testing became our life." Manning, for one, made more trips than he can count to the world's largest vacuum chamber, at a NASA lab in Sandusky, Ohio. That was the most Marslike place to drop air bags onto volcanic rubble, and also to test the 53 explosive devices that did everything from ejecting the parachute to freeing the air bags.

Meanwhile Pathfinder's scientists were laboring to make sure that the probe wouldn't go all the way to Mars only to crash on a boulder. They wanted a landing site that was not too steep and had plenty of rocks for Sojourner, the two-foot-long rover, to look at—but small ones, not yard-wide boulders that could threaten the whole lander. The images from the Viking spacecraft didn't help much, because they show details no

Pathfinder team was counting on it to have deposited a smorgasbord of rocks—solidified lava, rubble from meteorites, magmatic rocks that cooled beneath the surface and were exposed by erosion.

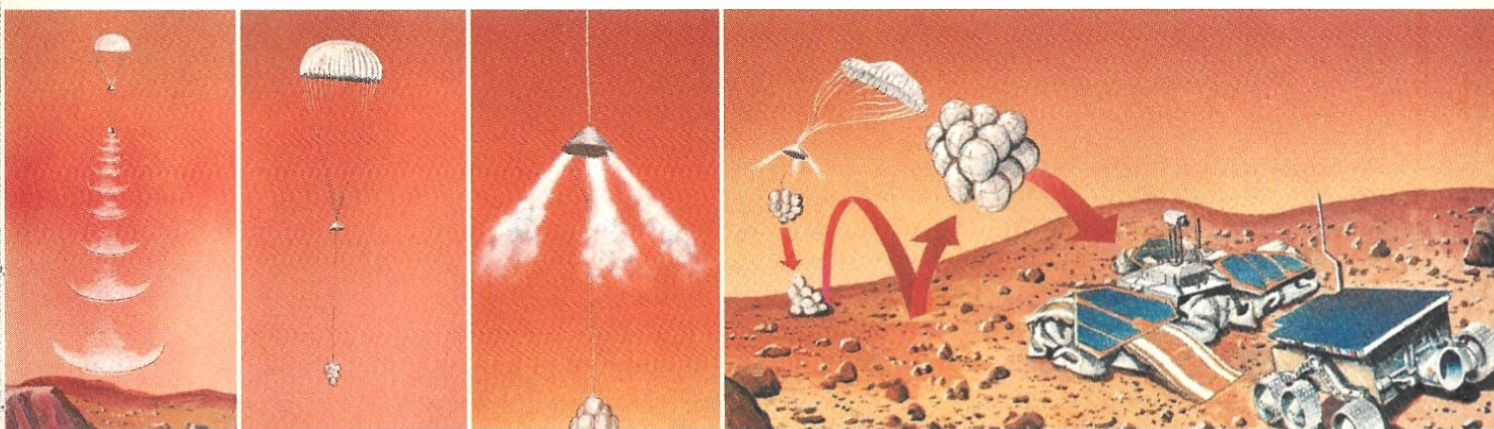
So when geologists saw the first panoramic images of the Martian floodplain, which showed abundant signs of the ancient flood, they cheered. Rocks nicknamed Shark, Half Dome, Moe, and Pumpkin—the nerds were getting punchy—stood in a line pointing north, the direction in which floodwaters would have flowed. The ground itself had ripples four yards high, and in the distance, on a hill called Twin Peaks, the scientists saw what looked like huge boulders left by the flood. Once Sojourner began analyzing the chemical makeup of the rocks



Sojourner sniffs silica in Yogi.

remelting before finally erupting. And there's also the bad luck theory: perhaps Sojourner just happened to pick some weird rocks.

Certainly the Pathfinder mission as a whole had some bad luck after its amazingly auspicious beginning. By October the lander, and thus the rover—whose signals are relayed to Earth by the lander—had fallen silent. The lander's batteries seemed to have died, causing the



Left: Mars, photographed and mapped by Viking, with a single line of topographic data (red) from the new Global Surveyor. Inset: Pathfinder's quirky landing had it aero-braking, parachuting, measuring its altitude with radar, and waiting for the last moment to brake and cut loose its cargo—the lander and its rover.

smaller than an average suburban lot. A team led by JPL geologist Matthew Golombek, however, filled in details from other sources. By bouncing radar signals from Earth off Mars, they pieced together a map of how steep its slopes were. Infrared images from Viking provided a clue to how rocky the surface was; rocks take longer to heat up than sand does, so after sunrise a rocky surface gives off less heat radiation.

After analyzing dozens of potential sites, Golombek and his group chose Ares Vallis, a large floodplain in Mars' northern tropics. It appeared reasonably free of large rocks, and it was scientifically interesting because it is thought to be the site of a great flood a billion or more years ago. That flood had swept north down from the highlands, and the

with its handy little alpha proton X-ray spectrometer, however, befuddlement set in. The first five rocks turned out to be much alike—and all unexpectedly high in silica. "I'm still struggling with it," says petrologist Harry McSween of the University of Tennessee, the Pathfinder team's lead rock expert. "It surprises me that the silica content is this high. It surprises me that all the rocks look alike."

There are several theories to explain the results. The most provocative holds that Mars once had drifting tectonic plates, as Earth does now; where plates collide on Earth, volcanoes spit out lava called andesite that is rich in silica. Other theories attribute the high silica content to more mundane geologic processes, such as lava rising near the surface and going through cycles of solidifying and

radio and computer to become too cold to operate. But researchers think there's an outside chance of restoring contact when the spring sun warms Ares Vallis, and *Pathfinder's* radio, next August.

In the meantime, the Mars Global Surveyor arrived on September 12 and started aero-braking its way down to a shallow polar orbit, from which it will make a topographic map of the Martian surface—one that may reveal evidence of plate tectonics—as well as a chemical map of its composition. The next orbiter-lander pair is set for launch in December 1998 and January 1999. That orbiter will drop some novel little probes; shaped like spears, they will plunge into the Martian surface without any braking whatsoever, penetrating several feet in the hope of finding water. The lander, though, will descend onto the south polar region using conventional retro-rockets, as Viking did. When its design was completed, well before last Fourth of July, nobody even knew if the air-bag trick would work.

—Richard A. Kerr

One Thing After Another

AMERICANS HAVE KNOWN their share of emergencies in space, from *Apollo 13* to the balky door on the space shuttle, but this past year on the *Mir* space station was a different matter altogether. The Russian cosmonauts and their American guests were subjected to so many problems, including potentially life-threatening fires and air-pressure leaks, that the year blurred into an ongoing crisis marathon.

In 1993, when the United States and Russia decided to cooperate on the new International Space Station, sending American scientist-astronauts on a study-abroad program aboard the trusty old

when one of two canisters used as back-up oxygen burst into flames, filling the station with smoke and fumes and spewing gobs of molten metal. Fire extinguishers proved ineffective, and the crew watched for 14 minutes until the flames died out on their own. Although *Mir* had experienced a similar fire in 1994, this one was far worse: the two-foot-long flames threatened to burn through the aluminum hull, and they blocked the escape route to one of the two *Soyuz* spaceships that were docked with the station at the time. Months later, officials are still at a loss to explain how the oxygen canister could have caught fire.

Then in March, *Mir*'s main oxygen generators broke down. In April the crew had to shut down the air-purification system when coolant began leaking into the atmosphere; for a while the cabin temperature reached nearly 90 degrees. By now mission control in Moscow was beginning to attract a great deal of media attention. Reporters were snapping up quotes from grumpy Russian space agency officials. *Mir*'s commander, Vasily Tsibliyev, was also getting some publicity. Around this time it became more widely known that he carried a plastic rabbit and liked to consult his astrologer.

Then, on June 25, came the main event. Tsibliyev was using a joystick to dock the unmanned *Progress* cargo vessel with *Mir*. This procedure would have been routine, except Tsibliyev was operating it without *Mir*'s radar, which ordinarily gives the vessel's distance and its rate and angle of approach. Mission control worried about getting spare units out of the radar factory, located in a former Soviet republic, and just in case the cur-

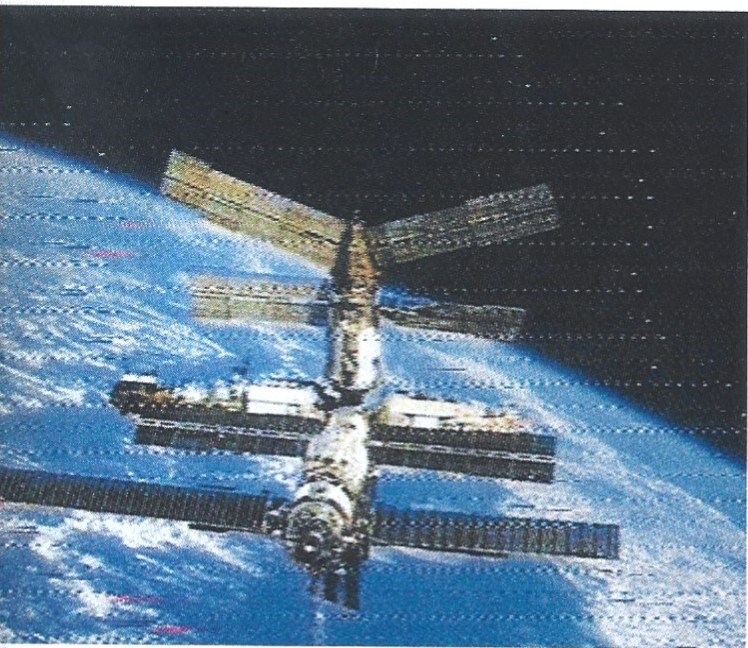
A cosmonaut on a repair mission to *Mir*'s Spektr.

rent unit should fail, they thought the crew should learn how to dock *Progress* without it.

Having switched off the radar, Tsibliyev eyeballed the entire maneuver with the aid of a video camera mounted on *Progress*. He found himself staring back at *Mir* against a backdrop of moving cloud cover, which may have distracted him. What's more, on that particular day the *Progress* vessel happened to be heavier than normal, and the pressure in the braking thrusters was lower than normal. Taking those things into account, Tsibliyev fired the braking thrusters a bit longer than usual—but something still went wrong, and the ship failed to stop. The crew heard a loud thump. Seconds later, they felt the terrifying tug of decompression in their ears.

The collision ruptured the hull of Spektr, one of *Mir*'s six modules, which happened to be both the lab and the sleeping quarters of Michael Foale, the American guest at the time. The immediate crisis was over in a few minutes, once the crew had sealed off the hatch to Spektr. But that meant cutting off its solar panels from the rest of the ship, putting *Mir* at half power.

The mishaps weren't over. On July 16 cosmonaut Alexander Lazutkin accidentally disconnected a power cable that shut



Mir, with the damaged Spektr module on top.

Mir, which began operating in 1986, seemed like a good idea. Beyond learning how to keep fit in zero-g, it was hoped that the astronauts would imbibe the culture of long-term missions and, who knows, perhaps even acquire some of the Russians' legendary imperturbability in the face of the unexpected. Aboard *Mir*, U.S. astronauts were told to mind their research and keep their noses out of operations. And that's where things stood as the year began.

The mishaps started in February,



off *Mir*'s computer, crippling its gyroscope and throwing the station into a slow spin, its solar panels pointing uselessly into the dark void of space. On Au-

gust 5 the only working oxygen generator failed, forcing the crew to rely once again on backup canisters. Throughout this chaos, the Russians were deliberating over just how and when to repair the collision damage, which required a tricky internal spacewalk into the darkened, frozen *Spektr*, and who was going to do it. The normally unflappable Tsibliyev—whose initial response to the crisis was to cry, “We are alive, thank God!”—came through the ordeal emotionally exhausted. Having developed an irregular heartbeat, most likely from the extreme stress, he was deemed unfit to perform the repairs.

The new crew sent in August didn't have an easy time either. The ship's computer failed several more times. Even the successful repair mission on *Spektr* on August 22 was marred by one astronaut's leaky glove. And on September 15 a U.S. military satellite came to within 500 to 1,000 yards of *Mir*, forcing the crew to take refuge once again in the *Soyuz* capsule, to be ready for a quick getaway in the event of a collision.

Once the situation stabilized, the finger-pointing started in earnest. Back on

the ground, Tsibliyev took a lot of heat from the Russian press and from his superiors at Star City, the cosmonaut training center, for his role in the fiasco; most likely his days as a cosmonaut are over. He, in turn, blamed *Mir*'s woes on the crumbling Russian infrastructure. Not only are replacement parts hard to get, he said, but balky communications satellites forced the cosmonauts to perform tricky operations only when the station happened to be over Russia, even if it meant disrupting their night's rest.

Like it or not, by autumn NASA had become less of a customer and more of a partner in *Mir*. Astronauts were assuming a bigger operational role—Foale, for instance, had briefly been considered as Tsibliyev's replacement for reconnecting the cables to *Spektr*, something that would have been unthinkable a few months before. Moscow was now consulting NASA on major decisions. Of course, not everybody was thrilled with the new arrangement. Representative James Sensenbrenner, a Republican from Wisconsin and head of the House Science Committee, concluded that *Mir* was overdue for the scrap heap and

TO ALDEBARAN AND BEYOND The *Pioneer 10* space probe—the farthest-traveling man-made object in the universe—came to the end of its mission this past year, after a quarter of a century of scientific exploration. When NASA launched it in 1972, the probe was meant to survive only a 21-month mission to Jupiter. Crossing the asteroid belt without incident was its first achievement; then it sent us the first close-up photographs and scientific measurements of Jupiter, confirming that the giant planet is mostly gas and liquid. Curving past Jupiter, it became the first spacecraft to use a planet's gravitation to fling itself along, a maneuver that later became standard procedure. Finally it showed that our solar system is larger than previously thought: when the mission ended, with the probe 6.2 billion miles from Earth, it was still detecting solar-wind particles, indicating that it had not yet crossed the heliopause—the boundary between the solar system and interstellar space.

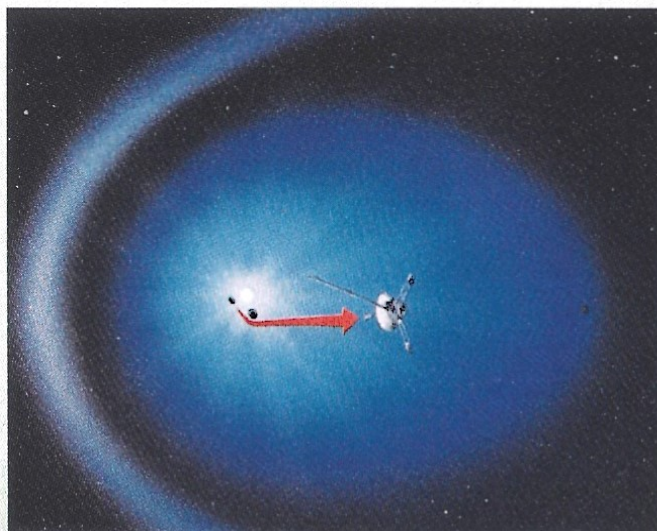
Mission planners had hoped to find that boundary, but by last March only 6 of *Pioneer*'s 12 instruments worked, and there was only enough power to operate one of them. “There was still interesting information coming back, but it takes several million dollars to operate the spacecraft,” says Larry

Lasher, project manager at the NASA Ames Research Center in Mountain View, California. So NASA decided to stop spending the money on sending commands to the probe and analyzing its data and formally ended the mission. Controllers at Ames, however, will continue listening to *Pioneer*'s faint radio beeps until its battery finally dies next spring; they're using that signal to train for a future lunar mission. “By this fortunate circumstance we are able to keep in touch with *Pioneer*,” says Lasher. “I think when it stops its signal, that will be the end of an icon—like the heartbeat's stopped.”

Even so, the spacecraft will fly on, headed for the star Aldebaran, some 68 light-years and a 2-million-year journey away. Lasher is confident *Pioneer* will make it to Aldebaran and beyond; the space it must traverse is fairly empty, so a collision is unlikely. Thus the probe's informal mission will continue: its famous plaque of gold-plated

aluminum, depicting a man and a woman, the path of the probe, and the sun's location in the galaxy, is presumably still intact. “We came of age by sending a representation of us into outer space,” says Lasher. “If it were ever found, it would be wonderful. But it's a big space out there, a big galaxy, a big universe.”

—Michael M. Abrams



Saturn, 2004

pounded NASA officials for endangering the safety of U.S. astronauts.

NASA was unrepentant. "A lot's been made of *Mir*'s design life being five years," says James Van Laak, NASA's deputy director for the Shuttle-Mir program. "But what's really true is that the *Mir* was certified for five years—just like the space shuttles were originally certified for only 10 flights. Most of them have flown more than 20 flights. If I ask an engineer to design and certify a piece of hardware to operate 25 years in space, he'd say, 'I don't know how to do that. I'll design it as best I can to operate 25 years, but I'm only going to certify it for 5, and after 5 we'll have to take another look at it.' That's exactly the way the Russians have approached the design of the *Mir*." Only a week after Sensenbrenner's hearing, in late September, the agency sent up its sixth crewmember, David Wolf; it plans to replace him with Andy Thomas in late January, the last American astronaut scheduled to visit *Mir*.

NASA maintains that the year on *Mir*, though harrowing, has been a valuable object lesson. Whereas astronauts can always land the shuttle as soon as a crisis occurs, that's not generally an option on a space station. "On a space station you're much more like a ship at sea," says Van Laak. "You have to deal with a crisis to its conclusion. The option of getting in a lifeboat and coming home is certainly there, but because of the value of the ship, you save that for the last resort. These elements permeate the very design and operation of the space station and the training the crew receives."

Could this year of mishaps be a foretaste of life on the International Space Station, the first elements of which are supposed to be launched and assembled in space next June? "The kinds of things that happened on *Mir* can happen on a new space station as well as on an old space station," says Marcia Smith, a space expert at the Library of Congress. "It's part of the risk of human spaceflight." NASA, in fact, expects to see far more hardware failures on the ISS than on *Mir* simply because it will be so much more complex. "I guarantee that some of these problems will show up in some form in the International Space Station," says Van Laak. When the accidents happen, astronauts will just have to cope. And so will we.

—Fred Gutert

TEN OR TWENTY YEARS AGO, interplanetary space probes were built like battleships: big, rugged, bristling with instruments—and costing a boatload of money. Although NASA has been phasing out such missions, only in October did it finally launch its last: the *Cassini* probe to Saturn.

By 2004, if all goes well, *Cassini* will park itself in orbit around Saturn and loop around and around, taking readings and snapping close-ups of the planet, its gossamer rings, and its 18 moons—the same sort of work its cousin *Galileo* is now doing at Jupiter (see story next page). Like *Galileo*, *Cassini* is two probes in one. While the main craft orbits Saturn, a second probe, the European-built *Huygens*, will detach and fall into the atmosphere of Titan, Saturn's largest moon. Titan is a world unto itself: nearly as big as Mars, it has an atmosphere that astronomers think is laced with organic chemicals—

the building blocks of life. "There are only a few solid bodies in the solar system with thick atmospheres—Earth, Venus, and Titan," says planetary scientist Jonathan Lunine of the University of Arizona in Tucson. "And Titan is the best model for the Earth prior to the time when life began."

Cassini also resembles *Galileo* in that it carries radioactive plutonium—72 pounds of the poisonous stuff, which provides heat to power the probe beyond Mars. The risk of that much plutonium being accidentally released into the atmosphere, either at launch or when *Cassini* flies by Earth for a gravity assist in August 1999, drew a great deal of protest, as did the 1989 launch of *Galileo*. But in a perfect replay, *Cassini* headed off into deep space without a serious hitch.

—Sam Flamsteed

***Cassini* takes off: The last of the interplanetary behemoths.**



ONE LAST TRIP Timothy Leary, who was a Harvard psychologist and many other things, rocketed into orbit last May. Or at least part of him did. "We launched a seven-gram sample of his ashes—about the amount that would fit inside a lipstick," says



Chan Tysor, president of Celestis, which has started a space-age mortuary business. Leary's was one of 24 ash samples on the maiden launch—he was accompanied by Gene Roddenberry, creator of *Star Trek*, and Gerard K. O'Neill, a Princeton physicist and the author of *High Frontier*—but Leary was the only one who had asked to be on board. The two dozen capsules hitched a ride into space



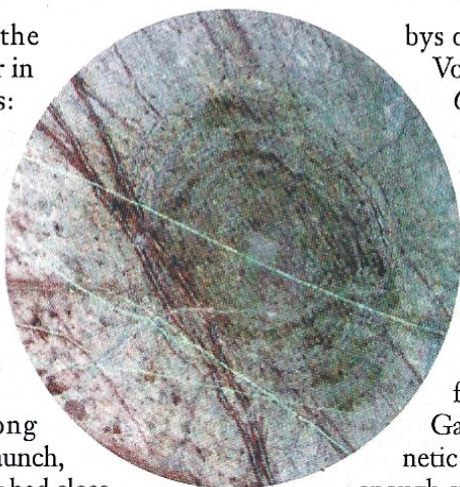
on a Pegasus XL rocket that was carrying a commercial satellite, and they will orbit Earth for approximately three years in the spent final stage. Celestis will keep track of that stage so fans and mourners can know at any time where the ashes are—especially when they reenter the atmosphere, at which time the rocket will form a shooting star, which will be visible if it happens on a clear night. According to Tysor, just days before his death Leary was watching a promotional video showing that burst of light when he "jumped up out of his wheelchair and said, 'That's me! I want to be the light!'" Becoming the light costs \$4,800 per passenger.

—Michael M. Abrams

A Flower-Petal Path Among the Moons

THE NEWS from the moons of Jupiter in 1997 was as follows: Ganymede definitely has a magnetic field; Callisto does not; Io has more volcanoes than ever; and Europa may have a liquid ocean surging underneath a thin crust of ice.

Still going strong eight years after its launch, the *Galileo* spacecraft had close encounters with the three outer Galilean moons this past year and snapped new photos of innermost Io from a distance. The probe's trajectory—the repeated use of one moon's gravity to change the orientation of the probe's ellipse around Jupiter and to fling it toward the next moon—is one of its niftiest traits and a big improvement over the one-time fly-



bys of the Pioneer and Voyager days. It gives *Galileo*'s handlers not only a closer look at its targets but also the novel luxury of a second look if they want one.

In 1996, for instance, *Galileo* had found evidence that Ganymede had a magnetic field—but not firm enough evidence to persuade everyone that the field was really Ganymede's and not Jupiter's. Last May, on the spacecraft's fourth encounter with the moon, researchers got the proof they needed. "The energetic-particle detectors saw particles behaving as if they were on closed magnetic-field lines around Ganymede," says project scientist Torrence Johnson of the Jet Propulsion Lab-

oratory. On Earth such particles would produce a shimmering aurora as they spiral down the field lines and crash into the polar atmosphere; on Ganymede, which has no atmosphere to speak of, they simply slam into the surface.

Yet the mere existence of the moon's magnetic field has surprising implications. It means Ganymede probably has a core of electrically conducting fluid that is in motion. In Earth's core the fluid is

Left: A meteorite dent in Europa's icy surface, and ridges that formed afterward. Below: Chunks of ice broke loose and refroze, forming the rough surface to the upper right.

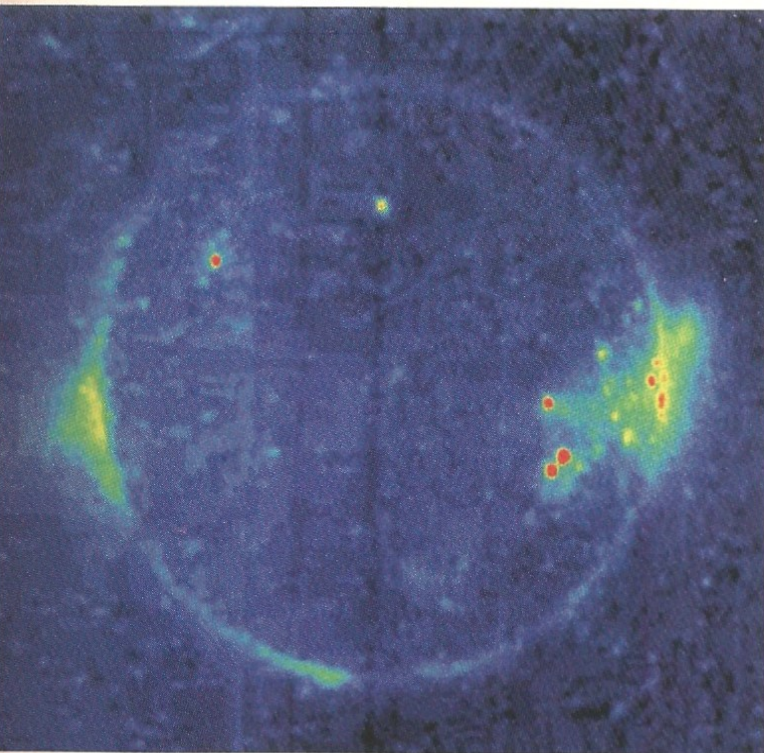


iron, and gravity readings by *Galileo*, which give a picture of Ganymede's interior, suggest that it has something similar. Though it is the largest moon in the solar system—about 1,000 miles wider than our own moon—it is much smaller than Earth. It should have shed its internal heat and frozen solid 3 billion years ago. Apparently it has been reheated somehow, and this reheating has caused its heavy metals to sink into its core. "That was really unexpected," says Johnson.

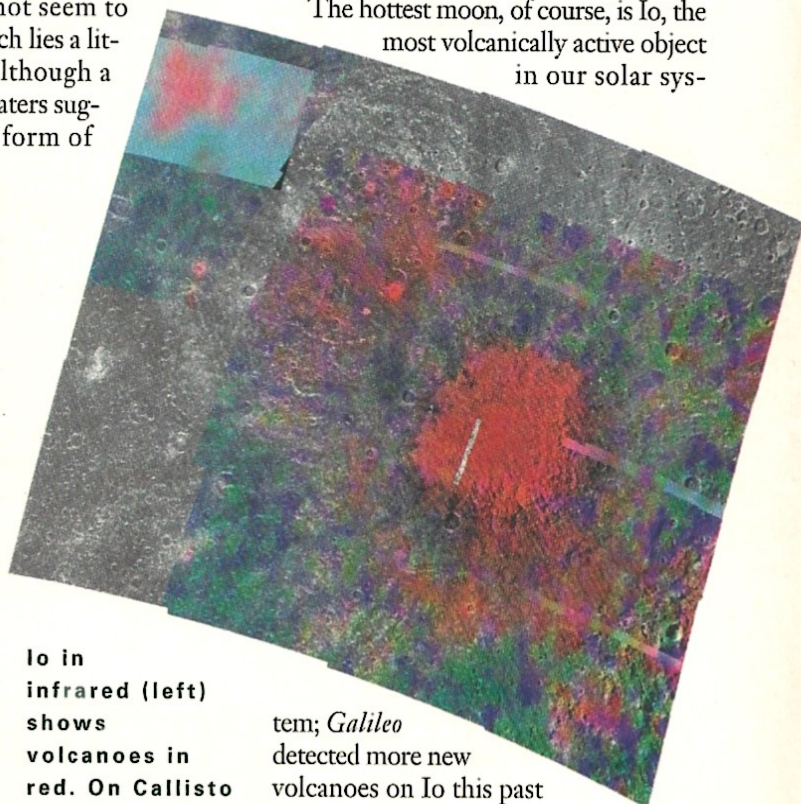
The only known method for this reheating is tidal pull; if a moon's orbit is not perfectly circular, the planet's gravity will act on it in an uneven way, stretching its insides back and forth and thereby heating them. That process certainly heats Io and Europa, which lie closer to Jupiter. It does not seem to heat Callisto, which lies a little farther out; although a dearth of small craters suggests that some form of

erosion is smoothing Callisto's surface, it is apparently dead inside and doesn't have an iron core. One possible explanation, Johnson says, is that Callisto is the odd moon out in an unusual gravitational symbiosis among the other three satellites—one that conspires with Jupiter's gravity to heat them but not Callisto.

The hottest moon, of course, is Io, the most volcanically active object in our solar sys-



Io in infrared (left) shows volcanoes in red. On Callisto (right) the red patch is a 120-mile-wide ice crater.



tem; *Galileo* detected more new volcanoes on Io this past year, bringing the total to 81. But the most interesting moon right now is Europa. Images taken in February provided signs of a liquid ocean, presumably of water, beneath an icy surface. "There are parts of the surface that look as if they have melted, with huge 10- to 20-kilometer ice rafts that have broken off the edge of the crust, moved around, and then frozen in place again," Johnson says. "You can't do that without having liquid water very close underneath the surface."

The images don't prove that Europa has an ocean today—let alone that it is inhabited, as every dreamer dreams—but they do strongly indicate that it had one in the geologically recent past, which is almost as good. "It is very hard to come up with a scenario where the moon is very hot and active for 99.9 percent of its history and then just froze yesterday," Johnson says. Anyway, *Galileo* gives him and his colleagues the chance to find firmer proof of the first ocean other than Earth's. At the end of 1997, the probe was scheduled to take two more passes at Europa. And in 1998, NASA is planning on seven more.

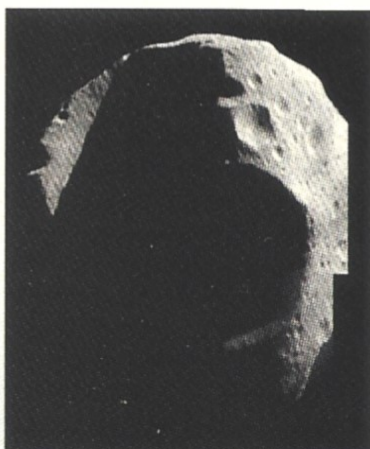
—Kathy A. Svitil

A FLYING BAG OF CHARCOAL

Asteroids are pretty easy to miss: they are generally small and dark and they flit about in odd orbits. So astronomers were elated when they realized that the Near Earth Asteroid Rendezvous probe, on its way to a 1999 encounter with the asteroid Eros, would also get a passing glance at a 43-mile-long asteroid called Mathilde. During the 25-minute flyby last June, NEAR snapped pictures of Mathilde's black surface from a distance of 750 miles. "The thing has been battered. It's really smashed up," says Cornell astronomer James Bell.

"It's incredible that it even exists." Five gaping holes, created by giant impacts, dominate one side of Mathilde, and the asteroid is so lightweight, says Bell, that it must be either full of ice (but there's no sign of water) or a loosely packed pile of rocks held together by their own weak gravity. Those rocks are probably rich in carbon; Mathilde is uniformly blacker than charcoal. The real fun starts in January 1999, when NEAR begins a year in orbit around 25-mile-long Eros, culminating with a crash landing on that asteroid's surface.

—Jeffrey Winters



A large iceberg floating in the ocean. The tip of the iceberg is visible above the water, while the vast majority of the iceberg is submerged below the surface. Two red arrows originate from the text 'What you pay for.' and 'What you get.' and point to the visible tip and the submerged part of the iceberg, respectively.

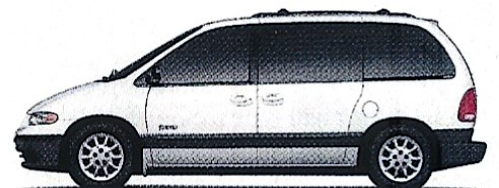
What you pay for.
What you get.



Plymouth Neon



Plymouth Breeze



Plymouth Voyager

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Craters Without Impact

IN THE FAR NORTHERN reaches of the Siberian tundra is an enigmatic place called Popigai. The high cliffs along the rivers there are made of rock that shows signs of once having been completely melted, and satellite images reveal that the tundra actually forms a giant ring-shaped depression 60 miles across—which suggests that Popigai is a vast meteorite crater. Last July a team of Canadian and Russian scientists announced that they had determined when the meteorite hit: 35.7 million years ago, give or take 200,000 years. They calculated that date from the amount of radioactive argon that had decayed in the rocks since they resolidified after the impact. Remarkably, in 1995 other researchers had pinned the age of a 50-mile-wide crater now buried in the Chesapeake Bay to almost exactly the same time.

These two impacts—the two biggest in the past 65 million years, and among the biggest of all time—struck Earth with a sudden double punch that might even have been simultaneous. Impacts this size are so rare that the timing was almost certainly no coincidence; perhaps a pair of gravitationally bound asteroids happened to cross Earth's path. Both impacts seem to have made themselves felt around the world: the Popigai impact was most likely responsible for layers of debris that were dug up in the 1980s in Italy, while the Chesapeake crater is probably responsible for bits of quartz scattered from Georgia to Barbados.

The most famous impact of all is, of

course, the one that occurred 65 million years ago at the end of the Cretaceous Period, scooping out a 125-mile-wide crater off the Yucatán coast. Most researchers now agree it wiped out the dinosaurs and many other forms of life. You'd think, then, that the combined blast of Popigai and Chesapeake would

have had a similarly huge effect, and around 35 million years ago there were indeed some radical changes going on. Algae, crustaceans, and mollusks were going extinct in large numbers, while primitive whales were replaced by modern groups. On land, dense forests gave way to more open habitats, and early hoofed mammals and primates were supplanted by new forms. In the 1980s, when geologists in Italy first found layers of impact debris that seemed to coincide with these extinctions, some researchers thought they had found another smoking extraterrestrial gun.

Since then, however, paleontologists have shown that there were actually two peaks of extinction, one 37 million years ago and the other 33 million years ago.

Neither coincides with the Popigai-Chesapeake impacts. "The one at 37 million is way too early—nothing has hit Earth yet—and the one at 33 million is 2 million years too late," says Donald Prothero, a paleontologist at Occidental College in Los Angeles. In fact, when the impacts occurred 35.7 million years ago, nothing happened. "The sizes of the Popigai crater and the Chesapeake crater are both pretty impressive," says Prothero, "but the animals didn't give a damn. They walked right through it."

According to Prothero, these extinctions were most likely caused by long-term global cooling and changes in the ocean circulation brought about by continental drift. The new dates on the impacts, he argues, call into question the Cretaceous-inspired tendency to link impacts with mass extinctions in general. "It couldn't be more obvious. This is one case of major impacts that had no effect, while major extinctions were occurring. Most of the so-called correlations between impacts and extinctions have been pretty frayed. If you just

step back, you can see this bandwagon to blame everything on impacts was premature."

—Carl Zimmer



The Popigai crater seen from space: Half of a cosmic one-two punch that left life untouched.



Wee Comets Again

COULD LOU FRANK BE right after all? Twelve years ago, the University of Iowa space physicist startled his colleagues with an explanation for tiny dark spots in satellite images of the upper atmosphere. The spots, said Frank, marked places where house-size snowballs, flying in from space 20 times a minute, were expiring in clouds of water vapor underneath the satellite, briefly blocking its view of the atmosphere's ultraviolet glow. A steady drizzle of comets throughout Earth's history, he added, would have been enough to fill the oceans. Nonsense, said most space scientists: the spots were just bad pixels in the satellite's camera.

Now Frank has flown a far more sensitive camera aboard a new spacecraft called *Polar*. To the surprise of nearly everyone but Frank, the camera seemed to see the spots again, hundreds of miles above Earth. This time, though, each spot filled not just one pixel but ten or more; the spots appeared in successive frames, and they moved from frame to frame, just like objects streaking in from space. The camera also picked up long, glowing trails, apparently made of sunlight-shattered water molecules. Last spring Frank declared victory. "It was a shock to a lot of people that

it turned out to be right," he says.

Within weeks another satellite had come to his support: it had detected about 50 percent more moisture than expected in a layer of atmosphere about 50 miles up. The evidence was enough to convince some former unbelievers—but far from all—that Frank's spots are real. "I don't know how else to get that water up there unless you just put it in by hand," says Thomas Donahue of the University of Michigan. Says Robert Meier of the Naval Research Laboratory, "I'm certainly willing to acknowledge that he's observing something."

But is it tiny comets? All the old objections to the idea remain. On the moon, seismometers left behind by the Apollo astronauts should have picked up a drumroll of comet impacts, but they haven't heard a thing. "And why the hell isn't Mars inundated with water?" asks Donahue. Alex Dessler, a space physicist at the University of Arizona in Tucson, argues that the vaporizing comets, if real, would be obvious to anyone looking up. "They would be as bright as Venus," he says. "In some cases, as bright as the full moon."

Frank has all his old answers—his comets, unlike ordinary ones, might be so fluffy they hit the moon with nary a tremor; on Mars the comet water is

hiding under polar ice caps; and amateur astronomers are dismissing the brief flashes of light they see as insignificant. Dessler and others think it's more likely that Frank's spots are inconsequential. "I'm firmly convinced there are no small comets," he says. "Once again we're being shown an instrument artifact"—cosmic-ray tracks in the detectors or random fluctuations in the electronics.

Dessler has a long history as a critic. But the scientist responsible for a second ultraviolet camera aboard the *Polar* spacecraft, space physicist George Parks of the University of Washington in Seattle, is also skeptical about Frank's spots—because his camera has seen spots, too. "Both instruments show dark pixels, but we come to different conclusions," Parks explains. "I can account for all the dark spots that I see through instrument artifacts."

Yet how could the spots be mere noise, Frank asks, if they cover multiple pixels, move like comets, wobble as the spacecraft wobbles, and show up in both cameras? Frank says he wants to stop debating whether tiny comets exist and move on. Along with Donahue, Meier, and others, he hopes to persuade NASA to fund a small satellite specially outfitted to study them. "What we need to do is go up to 600 miles and watch a small comet break up over San Francisco," he says. "We need to go up there and greet them."

—Tim Appenzeller

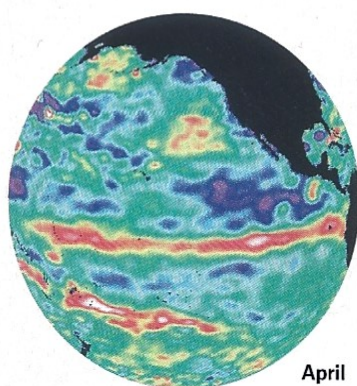
They Saw It Coming

THE FIRES THAT BEGAN burning in Indonesia this summer might have been quenched by the annual monsoons, but in 1997 the rain was too little too late. A thick coat of smog blanketed the region from Malaysia to the Philippines, and hundreds of people reportedly died of starvation and disease. The rain fell instead in places where it wasn't wanted, blasting the Pacific coast of Mexico with hurricane Pauline, which killed 400 people and injured thousands. Elsewhere

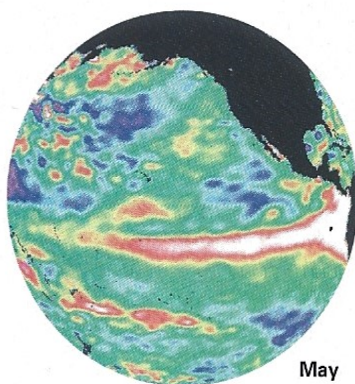
Using data from satellites, temperature-measuring buoys, and simulations of the ocean and atmosphere, two teams of meteorologists were able to forecast El Niño's latest arrival. To Jagadish Shukla of George Mason University in Fairfax, Virginia, this success marked nothing less than a scientific revolution. For 40 years meteorologists have been able to predict weather with reasonable accuracy a few days in advance—not individual thunderstorms, as we all know,

but the bigger movements of fronts and jet streams. Now, however, "we can predict climate, at least for the next season, with a very high level of confidence if there is an El Niño," says Shukla.

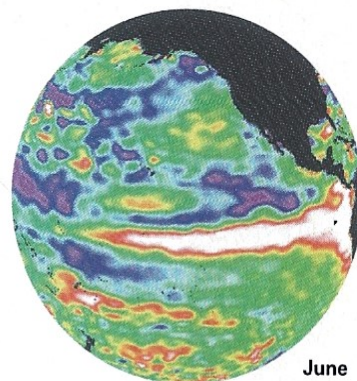
The benefits of knowing that El Niño is on its way can be substantial. Farmers can plant crops that will be suited to coming wet and dry weather. In Ecuador this past year, a special vaccination program was set up to protect children against waterborne diseases such as typhus. And last summer, futures traders invested heavily in wheat, on the theory that a Niño-induced drought in Australia was going to cut world supplies and drive the price way up.



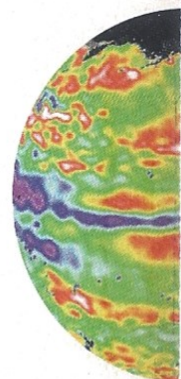
April



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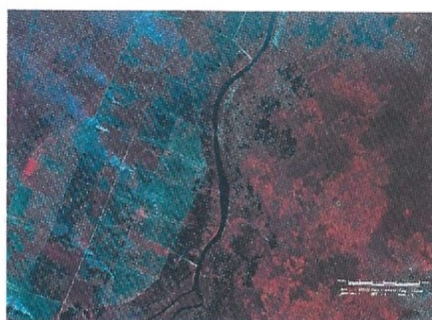
June



there was strange weather that was more welcome: warm waters on the coast of California lured tropical fish, while calm seas in the Atlantic put a damper on hurricanes there. In every case the prime suspect was the same: El Niño.

El Niño forms every two to seven years when the westward-blowing trade winds slacken over the equatorial Pacific. Sun-warmed water that's usually pushed up against Southeast Asia sloshes back toward the Americas. Above that warm pool, warm, moist air rises high into the sky and forms storm clouds. The change in the heating of the atmosphere by the storms helps shift the jet streams, thereby affecting weather around the world.

Until this past year the most powerful El Niño had been the one that started in 1982, which caused \$2 billion in damage from storms and floods in the United States alone. El Niño returned mildly in 1986, 1991, 1992, and 1994, but it wasn't until 1997 that it came back with a vengeance. By October it was as big as the El Niño of 1982 and still had many months to go. This time, however, there was a difference: earlier in the year researchers had predicted that El Niño was coming.

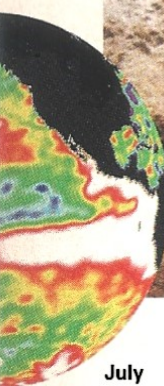
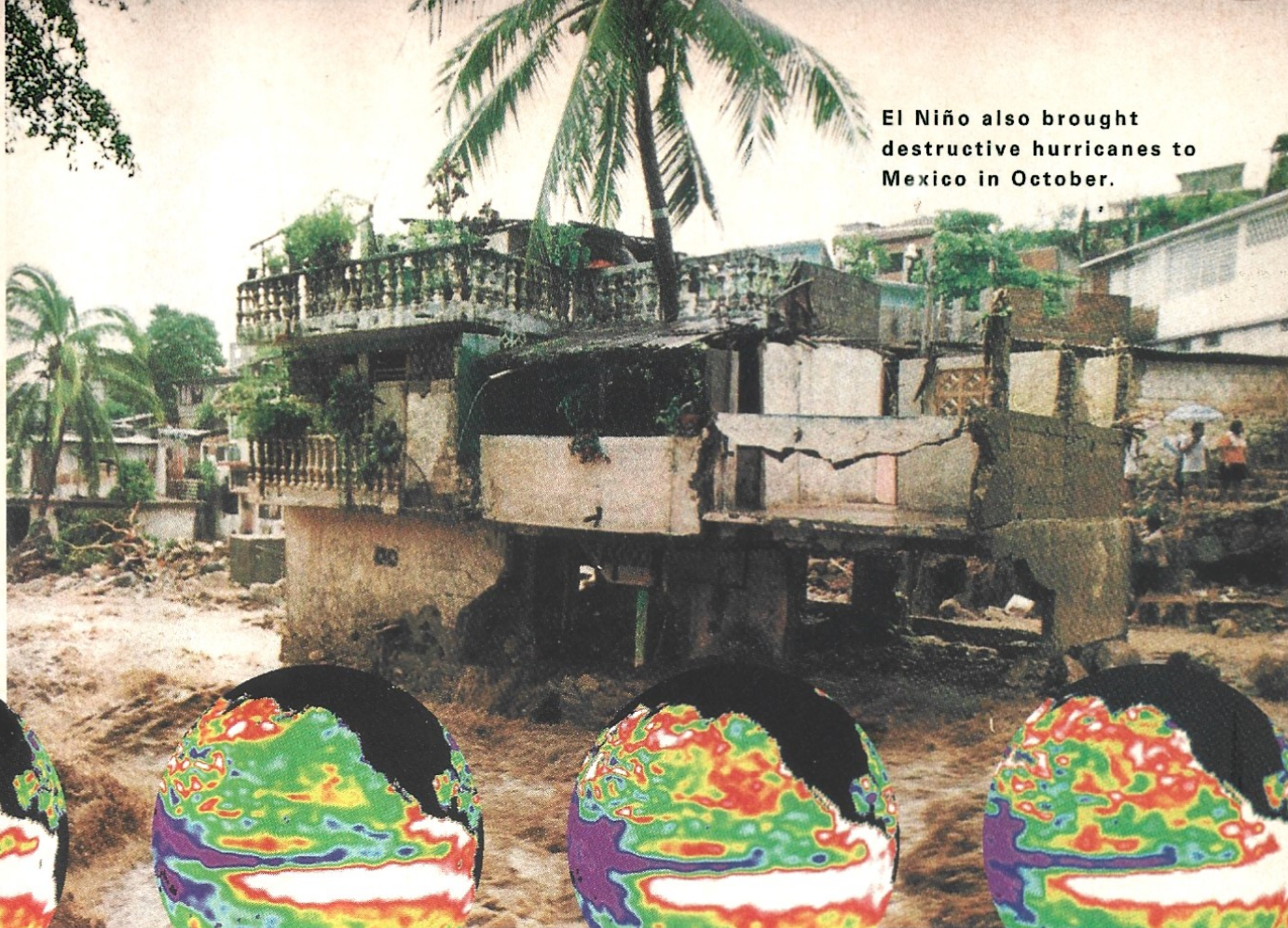


El Niño pushed warm water into the east Pacific this year and caused droughts in Southeast Asia. Man-made fires, such as in southeast Borneo (below) were thereby turned into infernos.

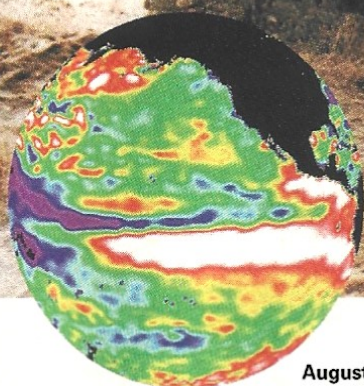
Those traders took a bit of a bath, however—above normal rainfall in September and October produced a healthy Australian crop. Developments like that help explain why not everyone shares Shukla's bullishness on El Niño forecasting. Michael Glantz, a senior scientist at the National Center for Atmospheric Research in Boulder, Colorado, says researchers still don't understand El Niño well enough for their models to reliably forecast its consequences. The pattern of flooding and drought that one El Niño can cause may differ radically from that of the previous one, he points out. "We haven't really seen all the combinations of impacts," Glantz says. "It's too early to have the level of confidence we think we have in forecasting this."

The latest El Niño is far from over, and how it plays out during the beginning of 1998 will offer one test of how well current models are doing. Accord-

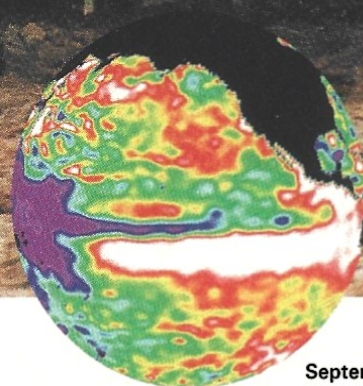
El Niño also brought destructive hurricanes to Mexico in October.



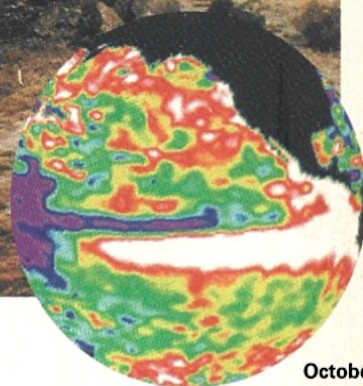
July



August



September



October

ing to a forecast from the National Weather Service in October, we can expect drier-than-usual weather in the months to come for Indonesia, eastern Australia, Central America, the Caribbean, northern South America, and

southern Africa. Meanwhile, more rain than usual will hit northeastern Argentina, Uruguay, southern Brazil, and the central and eastern equatorial Pacific. In the United States this winter, the far south should get more rain, and north-

ern states from the Rockies to the Great Lakes can expect a warm winter. "But Mother Nature can always fool you," warns oceanographer Bill Patzert at NASA's Jet Propulsion Laboratory. "It's only a probability." —*Jessica Gorman*

THE SALT SEA The idea that the Mediterranean had once dried up was first proposed more than two decades ago, when drill ships began pulling up extremely salty sediment cores from the seafloor. Salt deposits are left when seawater evaporates, and these dated from 7 to 5 million years ago, a time when much of the world's water was locked up in polar ice and tectonic activity closed the Strait of Gibraltar, cutting off the sea from the Atlantic. Last May, geochemist Klaus Wallmann of the GEOMAR Research Institute in Kiel, Germany, reported new evidence that those conditions had actually converted the Mediterranean into a deep, dry basin.

Off the coast of Crete, in

a two-mile-deep depression called the Discovery Basin (indicated by yellow dot), Wallmann and his colleagues found a large underwater lake of extremely salty brine sitting above a thick deposit of salt. This is not your average brine:



it is composed almost entirely of concentrated magnesium chloride, a salt that can only be produced when an evaporite salt called bischofite is redissolved in water. "Bischofite is the very last salt that is formed when seawater evaporates," Wallmann observes. "While we can't say for sure that this means there wasn't any water left in the Mediterranean, we know that more than 99 percent of it must have evaporated in order to produce the bischofite."

—*Kathy A. Svitil*

A Sleeping Mountain Wakes

THIS PAST SUMMER Montserrat, the 40-square-mile British colony in the Leeward Islands of the eastern Caribbean, was devastated by the eruption of

its Soufrière Hills volcano. It first began spitting steam and ash on July 18, 1995; over the next two years it swelled, trembled violently, and began to explode. It

gasped out ash plumes that rose above 40,000 feet before blanketing the island, and it sent pyroclastic flows—burning streams of volcanic rock, ash, and gas—flying down its flanks. Finally, on June 25, Soufrière Hills unleashed a particularly massive pyroclastic flow that devastated nine villages and killed at least ten people, with nine more missing and presumed dead. In early August, more flows virtually destroyed the capital, Plymouth, which lies near the foot of the volcano in the southern part of the island.

By September local authorities had declared the southern two-thirds of Montserrat off-limits, and more than half of the 11,000 inhabitants had been evacuated from the island. It's not likely they'll have much of a home to return to—if they ever can. Volcanologists at the Montserrat Volcano Observatory (established after the July 1995 eruption) predict that a major explosion, one that would shower the entire island with ash and rock, is "imminent." The scientific consensus, according to a report issued by the MVO, "remains that this is very likely to be a long-lived eruption that could last for years."

Volcanologists still have a long way to go before they'll be

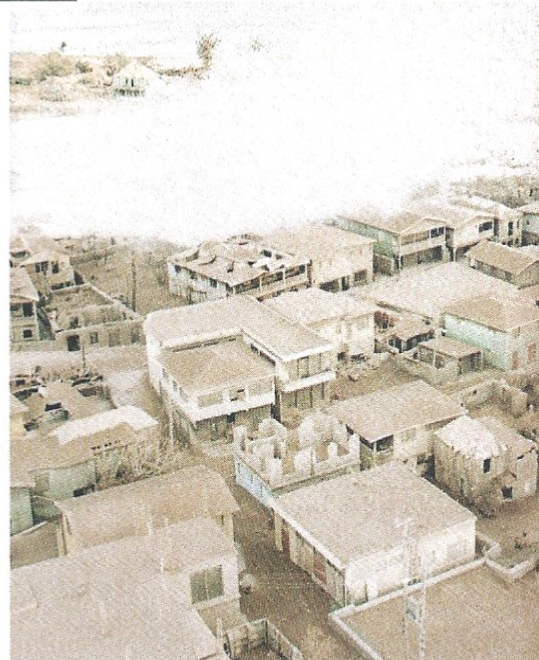
Kevin West/Gamma Liaison



TOASTY DOWN THERE Geologists have long wondered about the temperature of Earth's mantle—the thick layer of rock that stretches from 20 to 1,800 miles underground, sandwiched between the core and crust of the planet. Sticking a thermometer to that depth hasn't exactly been feasible, so researchers have used indirect methods. This year two geophysicists announced they may have found the answer in the barrel of a gun.

Kathleen Holland of Sandia National Laboratories and Thomas Ahrens of Caltech put pieces of olivine—a translucent gem—into an apparatus that is essentially a sealed giant high-powered cannon. They fired projectiles at the olivine at velocities up to four miles a second, creating a brief shock wave so intense it transformed the crystal structure of the olivine into two minerals thought to be major ingredients of the mantle—magnesiowüstite and perovskite. Seismic-wave data suggest that the lower mantle is partially molten, so the researchers blasted the rock to different pressures, looking for the levels at which it would start to melt. Every time the rock was hit, it gave off a heat-induced glow that the researchers could measure, and from that calculate its temperature.

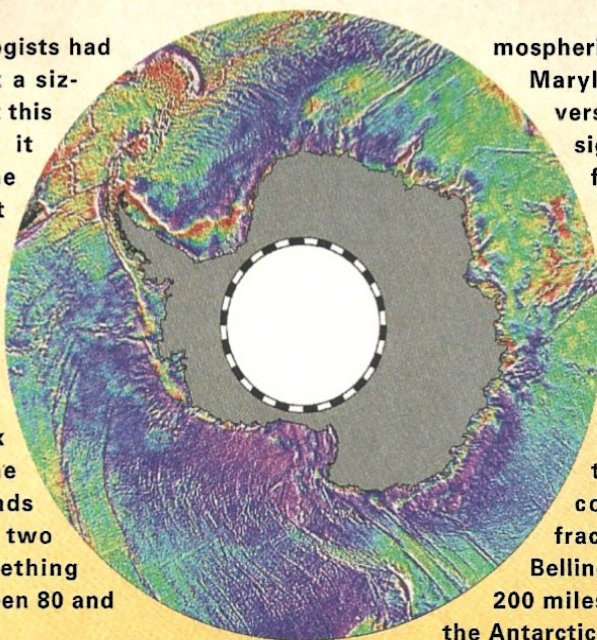
From these readings the researchers estimated the temperature of the lower mantle at no more than 7,300 degrees Fahrenheit—about three-quarters as hot as the surface of the sun. Knowing that temperature will help geophysicists understand how plumes of hot rock rise through the mantle, manifesting themselves at the surface as volcanoes and perhaps affecting the motion of the tectonic plates. "We're getting into explaining how such a layer of molten rock could exist at great depth," says Ahrens. "This layer may be the layer that feeds the volcanic edifices such as the Hawaiian chain and Iceland." —Lybi Ma



The eruption of this Soufrière Hills Volcano (above left) laid waste to two-thirds of the island of Montserrat.

ANTARCTIC PUZZLE Geologists had been wondering where to stick a sizable piece of Gondwanaland, but this past year they found where it belongs. Gondwanaland is the southern supercontinent that started breaking up some 180 million years ago. Reassembling it from its scattered pieces—Africa, Australia, South America, and Antarctica—is not too hard, except that to get a nice fit you have to break a chunk off Antarctica, move it up the coast and reattach it. This sounds like cheating, but last April two researchers reported that something like this really did happen between 80 and 60 million years ago.

The chunk in question includes the Bellingshausen Sea and probably even the neighboring Antarctic Peninsula, which curls up toward South America. The idea that a Bellingshausen plate had once separated from the main body of Antarctica was first suggested around a decade ago; tracks in the seafloor south of New Zealand were the evidence. David McAdoo of the National Oceanic and At-



mospheric Administration in Silver Spring, Maryland, and Seymour Laxon of University College London found clearer signs of this scenario by using data from the European radar satellite ERS-1. The radar soundings reveal the topography of the sea surface—and thus indirectly of the seafloor.

When McAdoo and Laxon made an ERS-1 map of the seafloor off Antarctica, they discovered previously unknown fracture zones in what is now the ice-covered Amundsen Sea. Those fractures represent the tracks of the Bellingshausen plate as it moved 100 to 200 miles northeast, presumably carrying the Antarctic Peninsula to its present position.

A trough paralleling the coast marks the former rift between the Bellingshausen and Antarctic plates, a rift that was healed again around 60 million years ago. "We've found firm evidence for an extinct plate boundary between the Bellingshausen and the rest of Antarctica," McAdoo says. "What we need now is for people to survey with ice-breakers to confirm it."

—Kathy A. Svitil

able to predict eruptions precisely and accurately. But last May a team of geophysicists from Stanford reported the first successful test of a promising new system—one that relies on satellite measurements—at Kilauea on Hawaii. Susan Owen and her colleagues deployed a network of 13 stations on either side of the rift that surrounds the Napau crater. The stations are tied into the Global Positioning System of satellites, which can be used to calculate their positions to within half an inch. The relative change in dis-

tance of the stations tells the researchers how the ground around the volcano is shifting—for instance, as it swells with magma before an eruption.

Eight hours before Kilauea's January 30 eruption—which didn't kill anyone—the GPS data did indeed show that the rift was expanding. By the time of the actual eruption, the crack had opened by nearly eight inches. The Stanford team couldn't predict the eruption, unfortunately, because their current system gives them data only after a 24-hour delay. "If we had this set up in real time, and we saw that there was a significant

Scientists detected changes at Kilauea eight hours before an eruption (below and right).



amount of extension going on in a particular place," says Owen, "we'd be able to say with fairly good certainty that there would be an eruption." She and her colleagues hope to have such a system in place on Kilauea within a year. Montserrat might still be able to use one, too.

—Kathy A. Svitil

Man's Oldest Friend

WHEN DID the first wolf trade its wild ways and freedom for the occasional pat on the head and meal-ticket lifestyle of doghood? Fossils found in Germany some years ago suggested that the evolutionary path to pugs and other unlikely wolf heirs began around 14,000 years ago. But last June a researcher studying canine DNA announced that wolves were domesticated much earlier, probably more than 100,000 years ago.



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Evolutionary biologist Robert Wayne of UCLA examined a stretch of mitochondrial DNA from 140 dogs of 67 breeds and compared it with the same stretch from wolves, coyotes, and jackals. As one would expect, he found that dogs and wolves were genetically the most similar. Wayne also found a wide variety of DNA sequences in dogs. "The genetic base that established the first dogs seems to have been very broad," he says. "A large population of wild wolves were responsible for the genetic diversity we see in dogs today."

Based on their mitochondrial DNA, Wayne divided modern dogs into four separate groups, or clades. The clades reflect events deep in the canine past, and so have little to do with the familiar breeds, which were created by humans in

the last few centuries. It is possible, he says, that the four clades mean that wolves were domesticated on four separate occasions. But he thinks it more likely that they were domesticated just once and that the clades arose later, when dogs interbred with wolves that were still

wild. The DNA sequences in one clade, for instance, from breeds as varied as baset hounds and German shepherds, were nearly identical to sequences in gray wolves from Romania and western Russia—suggesting a comparatively recent mix between those dogs and wolves.

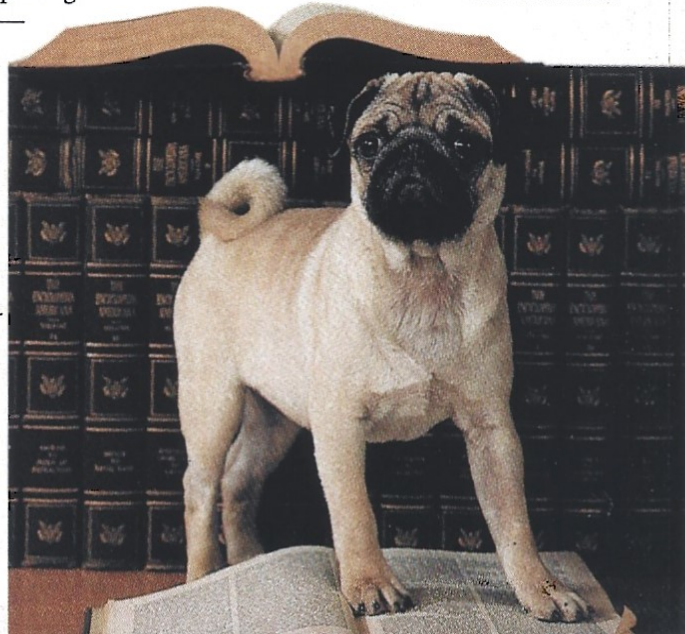
But Wayne's most surprising result is his calculation—based on the amount of time it takes for mitochondrial DNA to accumulate mutations—of when that first domestication took place: 135,000 years ago. Even if it is only roughly accurate, the date is astonishing because domesticating wolves implies much more than merely capturing a few pups and taming them. "They have to become stably

integrated into a human society," says Wayne. "They have to want to stay in that society more than they want to run away and join their wild brethren. That involves a socialization process that is quite profound. If you're a nomadic hunting-gathering society, how do you stably get progeny of that first tame wolf to become members of your society? If you think about horses and cattle, what happens if you don't confine them—they're outta there."

Were humans capable of such a feat some 100,000 years before settling down to invent agriculture? At a time, incidentally, when Neanderthals were just entering their heyday? "Wolves and humans were living in the same environments for perhaps half a million years, so there was ample time for interaction," says Wayne. "And it's interesting that a lot did happen around 100,000 years ago. Humans evolved bigger brains, they moved out of Africa—perhaps that's when wolves were first domesticated."

Many researchers, however, feel that dating based on a molecular clock is suggestive at best; mitochondrial DNA mutates rapidly, which makes it a better timepiece than ordinary DNA from the cell nucleus, but it may not necessarily mutate at a constant rate. And archeologists have found no evidence of any sort of domesticated animal even remotely close to 135,000 years ago. "That date has no possibility of being correct," says Stanford archeologist Richard Klein. "The fossil record is the ultimate proof." But Wayne argues that the earliest dogs looked much like wolves and so may have been overlooked in the archeological record. He thinks they may have served as hunting companions.

—Shanti Menon

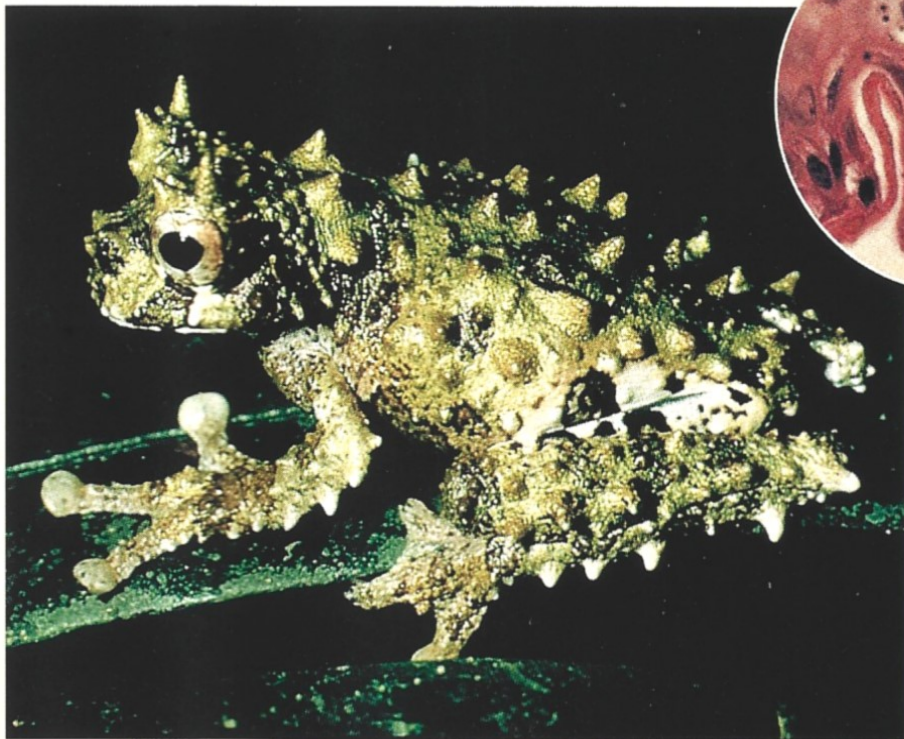


A Plague on Frogs

SOMETHING IS KILLING FROGS all over the world—or maybe it is many things that are responsible for the widely observed but for the most part poorly documented declines in amphibian populations. Biologists have blamed acid rain, the pollution or eradication of wetlands, and the shrinking ozone layer, but they have found solid

Karen Lips, a biologist at St. Lawrence University in Canton, New York, has been studying tree frogs in the Fortuna Forest Reserve in Panama for the past

A deadly protozoan that attacks frog skin (inset) is killing frogs in Panama and perhaps elsewhere.



a veterinary pathologist in Maryland.

When Green examined the frogs under a microscope, he saw that their skin had swollen, most notably in a specific part of the lower belly called the drink patch, which acts like a sponge that takes in most of the frog's water. Looking more carefully, he found a microbial parasite infecting the skin. The frogs also breathe through their skin, and

Green suspects that the parasite gradually dehydrates and suffocates them.

He doesn't know if the microbe is a fungus or a protozoan, but it appears to reproduce and spread by releasing spores through the frogs' pores.

Lips and Green have no idea why the parasite should be decimating Panamanian frogs now in particular—has it been recently introduced to Panama, or is it a native microbe that frogs for some reason have become more susceptible to? Nor do they know whether it affects frogs outside Panama. During the coming year they plan to look for it in frogs from around the world. A very similar parasite has already been identified in frogs in Queensland, Australia. —Lybi Ma

evidence in only a few cases. This past year yet another suspect turned up in Panamanian frogs: a previously unknown parasite.

seven years. During this past year she came across countless dead or dying frogs. She collected and preserved 50 frogs of 10 species and sent them to D. Earl Green,

ANTIC FROGS When the tiny poison frogs of the Amazon are born, they are harmless. Only mature frogs secrete a protective coating of deadly

toxins—so deadly, in the case of one species, that a single inch-long amphibian has enough poison on its skin to kill a hundred people. How do the frogs produce such toxic stuff?

This past year herpetologist Jana-lee Caldwell of the University of Oklahoma in Norman found the answer: they eat lots of ants. Caldwell examined the stomach contents of nine species of frog from Central and South America ("Imagine looking into a stomach the size of a speck," she says) and



found 135 species of ant, which contained 15 to 20 different toxic alkaloids. In fact, 70 percent of the diets of the most deadly frogs, such as *Dendrobates auratus* (left) consists of ants. Other, less toxic frogs, like the Ecuador poison frog above, eat less noxious insects. —Lybi Ma



Them

SOUTHERN CALIFORNIA residents, having weathered fire, floods, riots, and a 6.7 earthquake in recent years, are now enduring—what else?—pestilence. The culprit is *Linepithema humile*, a tiny ant that hitchhiked to New Orleans aboard ships from Argentina (or perhaps Brazil) sometime around the turn of the century and has since spread over much of the United States. Last August, University of California at San Diego researchers reported that *Linepithema*, besides being a tenacious household pest—“They don’t sting or bite humans, but once inside your house they’re a pain to get rid of,” says graduate student Andrew Suarez—is also wreaking agricultural and ecological havoc in California.

The Argentine ants, as they’re called, are prolific and mobile. Each colony contains multiple queens, each queen produces thousands of eggs a

day, and the same ant family, UCSD ecologist Ted Case has discovered, may found colonies that are miles apart. Too much rain, or too much heat, and the ants flee their shallow nests to colonize the cooler, sheltered habitats of humans—in droves.

The threat they pose to agriculture is more indirect

but involves perhaps more serious consequences. “The ants love honeydew, the sweet excrement of aphids,” says Suarez. “They’ll actually cultivate aphids and protect them from other predators.” Aphids, of course, are the bane of farmers and backyard gardeners alike, destroying tomatoes, citrus fruits, and

other crops by sucking juices from leaves and stems.

While pampering aphids, the Argentine invaders are savaging California’s native harvester ants, ecologically useful insects that consume, and thus help spread, plant seeds. Argentine ants don’t eat seeds, but in battles for territory they mob and dismember the larger harvester ants, as shown in the photo at left. The impact of that battle reverberates up the food chain—to horned lizards, for example, which prey on harvester ants. By strapping dime-size radio transmitters to lizards’ backs, the UCSD researchers found that as soon as *Linepithema* drives the native ants out of an area, the lizards invariably leave, too, and change their diet from ants to beetles. What effect that has on the lizards’ ability to grow and reproduce or on their own predators—such as birds and snakes—is still unknown.

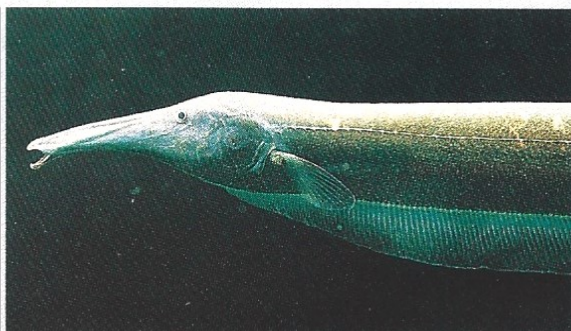
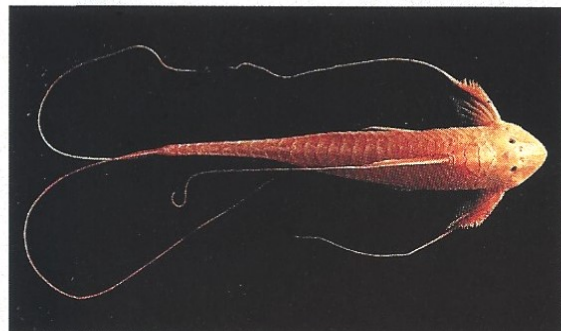
—Mark Wheeler



AMAZING AMAZONIANS The murky depths of the Amazon River harbor fish that are little known to science, which is why John Lundberg took his research team there this past year. In a 65-foot boat, Lundberg, an ichthyologist at the Univer-

sity of Arizona in Tucson, trawled over 2,000 miles of the Amazon, lowering his nets into water as deep as 50 feet and filling 33 large drums with fish—mostly catfish (left photo)

and electric fish (right). Those species do well in deep river channels because they don’t rely on sight but instead have special organs that detect the electric fields of their prey. “There’s no light penetration beyond a few inches because there’s



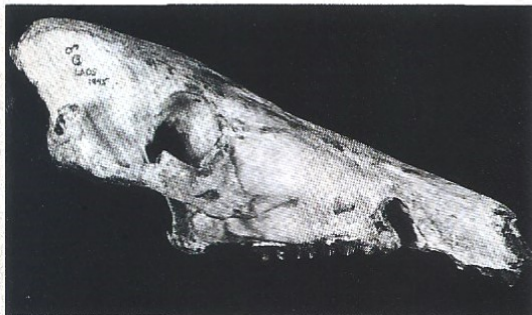
375 species of fish, including about 35 new ones, bringing estimates of freshwater species in South America to around 5,000—about five times the North American total. Some of the weirder new species include tiny catfish less than two inches long, electric

fish that feed exclusively on the tails of smaller electric fish, and a catfish with a fingerlike organ, probably electrosensitive, protruding from its chin. “To have that many different kinds,” says Lundberg, “and then to have some of them so obviously specialized to live there—they live nowhere else—it’s kind of a surprise.”

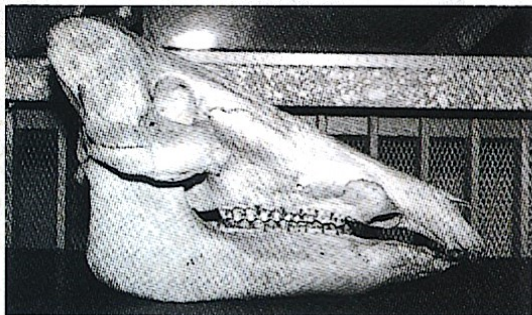
—Michael M. Abrams

In all, Lundberg caught more than

LOST PIG FOUND When Colin Groves unpacked this skull of *Sus bucculentus*, a Vietnamese pig (top photograph), he knew the animal hadn't been dead long. "It was still slightly smelly and had a bit of flesh on it," he recalls. This was strange because *S. bucculentus* was presumed extinct; no scientist had seen one—dead or alive—for more than a century. Two years ago, however, villagers in the heavily forested Annamite Range along the Laos-Vietnam border gave the skull to George Schaller of New York's Wildlife Conservation Society, allowing as how they had long en-



joyed hunting and eating the pig. Schaller sent it to Groves at the Australian National University in Canberra. After comparing it with a century-old skull in a Beijing museum



(above), and after some genetic tests on the flesh, Groves identified it this past year as *S. bucculentus*. It resembles the Javan warty pig, he says, which has short legs, a long snout, and a warty face. The Vietnamese *Sus* joins a growing list of newly discovered mammals from the isolated Annamite Range, including the antelope-like *Pseudoryx* and a new type of deer. "It's an exceptional habitat," says Groves, "very precipitous, extremely wet and humid, and difficult to get through. Things have survived there that have long gone extinct elsewhere."

—Josie Glausiusz

Scarce Sharks Netted



FOR MORE THAN 100 years the only known specimen of the Borneo river shark was a dried and mounted exhibit in a museum in Vienna. Now ten more can be found in a tank inside the house of a fisherman on the Kinabatangan River in Sabah, in the Malaysian part of Borneo. Some of the credit goes to Sarah Fowler, an ecologist with the World Conservation Union in England, who like other living scientists had never seen a river shark in Malaysia—even though she very much wanted to and even though people in fishing villages had occasionally reported finding them in their nets. "We had tried a lot of fishing, but we hadn't caught any," says Fowler. "It was obvious that we needed to work with people who were out fishing every day of their lives." One family agreed to preserve any sharks they caught in a tank of formalin until Fowler's next visit. Early this past year, they showed Fowler's team a small shark with beady black eyes and a blunt snout—it looked exactly like the museum specimen. Since then the family has caught ten sharks, all about a foot long and probably newborn, which means that sharks are breeding in the river. Fowler thinks that adult Borneo river sharks may grow, like river sharks in other parts of the world, up to nine feet long—too big for the fishermen's nets.

—Shanti Menon

White Penguin Spotted

THE LITTLE BIRD in this photo is a juvenile emperor penguin, discovered last winter on sea ice in Antarctica's western Ross Sea. Emperor chicks normally have a grayish down coat with dark wing and tail feathers, a dark bill and feet, and rings around their eyes. This chick—it was about five months old when biologist Gerald Kooyman of the Scripps Institution of Oceanography found it—is completely white, except for its brown or black eyes. (So it's not an albino, which would have pink eyes.) "We have seen birds that were partially white," says Kooyman, who has been studying penguins for some 30 years, "but never an all-white bird." It's unlikely that Kooyman will ever see this particular bird again. Soon after he discovered it, the bird fledged—it left the colony and em-

barked on a 2,000- to 3,000-mile hunting journey to the southern edge of the Pacific through hostile, predator-filled waters. The bird may not return home for four or five years—if it comes back at all. "I'd say its chances are not as good as another juvenile's," says Kooyman, "because of the coloration—it would certainly stand out like a beacon in deep water."

—Kathy A. Svitil



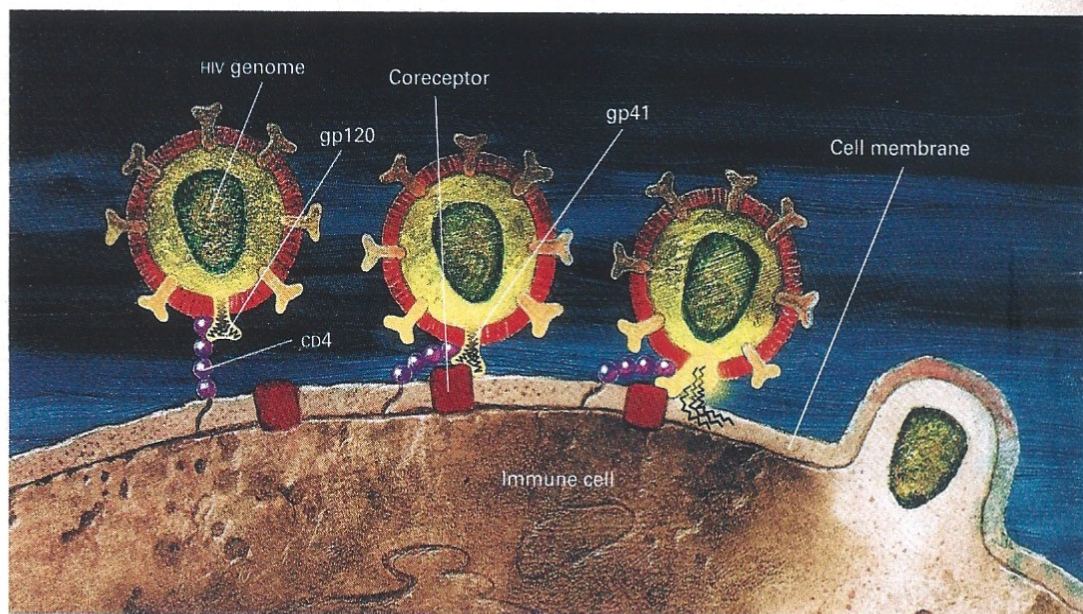
HIV's Harpoon

THE AIDS VIRUS has unique and devilish tricks that make it so deadly. But in one respect, researchers reported last April, it is much like the common flu: it uses the same type of harpoon to penetrate a cell and infect it.

HIV latches onto an immune cell with the help of a knobby structure. The top of the knob, which binds to a receptor on the cell surface, is a protein called gp120. The base of the knob is made of another protein, gp41. David Chan and his colleagues at the Whitehead Institute for Biomedical Research in Cambridge, Massachusetts, determined the structure of gp41 by means of X-ray crystallography—by observing how crystals of the protein scatter X-rays.

Each molecule of gp41, they found, contains a spiral region, and in the HIV knob three of these spirals entwine, forming a braidlike structure called a coiled coil. At the top the braid unravels, and the loose ends fall down along the grooves of the coiled coil. When the tip of the knob, gp120, latches onto the immune cell's receptors, it flips back like the lid on a tin can, releasing the coiled coil within. "It's rather like a harpoon that springs out—a barb that pierces the cell membrane," says Chan's

colleague Peter Kim. The virus then fuses with the cell membrane and dumps its genes inside. Coiled coils have been found in flu viruses, and their use in HIV, which



is not related to influenza, makes Chan and Kim suspect this is a common viral ploy.

Before HIV can launch its harpoon, though, it must first attach to CD4, a common receptor on immune cells, as well as to a coreceptor that helps position it properly—and this is where the virus's unique devilishness becomes more evident. In July molecular immunologist

Dan Littman and his colleagues at New York University Medical Center discovered two more coreceptors that HIV can use—one is on immune cells in the lymph nodes and the colon, the other is found only in the colon. That brings the total to six, which makes HIV exceptionally flexible. Trying to block one of these receptors, as some researchers have suggested, may therefore be a dubious approach to therapy. "If you develop a drug that blocks one receptor, the virus might

HIV binds to CD4, then to a coreceptor. That binding releases the "harpoon" that pierces the cell membrane and lets the virus in.

mutate itself," says Littman, "so you'll accumulate virus that can use another coreceptor and do just as much harm or maybe more." —*Josie Glausiusz*

Hope at a Price

AFTER YEARS OF DESPAIR, hope is returning to the lives of thousands of HIV-infected patients. The number of Americans newly diagnosed with AIDS in 1996 was 6 percent lower than in 1995—the first such decline ever—and the number of Americans who died of AIDS dropped a stunning 23 percent. The declines are due in part to a new class of antiretroviral drugs called protease inhibitors. This past year brought more evidence of their effectiveness.

In a report that appeared in *Science* in May, microbiologist Ashley Haase and his colleagues at the University of Minnesota Medical School in Minneapolis showed that a combination of three drugs, including the protease inhibitor Ritonavir, dramatically reduces virus levels, not only in the bloodstream but in the lymph nodes—the headquarters of HIV. Haase and his team biopsied the tonsils, which consist of lymph tissue, of HIV-infected patients. Over six months of

triple-drug treatment, the researchers watched the virus count in the tonsils drop by more than 99.9 percent.

The staggering drop was a welcome surprise, says Haase, but it doesn't show that the drugs can actually rid the body of HIV. For one thing, even after a 99.9 percent decline, 10 million potentially infectious viral particles remained in the patients' lymph systems. For another, antiretroviral drugs do not kill infected cells; they only arrest the spread of infection by blocking the manufacture of new virus. The traditional anti-HIV drugs, such as AZT, do so by blocking an enzyme the virus needs to copy its genetic mate-

rial into the host DNA. The protease inhibitors work by blocking the assembly of the virus itself. Both kinds of drugs leave cells that are already infected—whose DNA already contains HIV genes—untouched. If all those cells had a short life span, Haase explains, eradication of HIV in patients on combination therapy might occur within a few years. But the life span of HIV-infected cells is not known. As long as any of them remain in the body, they can reignite the infection as soon as the drug treatment is stopped or—if drug-resistant virus crops up—even before.

The drugs are not yet a cure, then, but by controlling the infection, they allow the immune system to heal and T cell counts to rebound. And that may permit researchers to come up with ways of tweaking the immune system to detect and kill the remaining HIV-infected cells. Fred Valentine at New York University Medical School is beginning a clinical trial that will combine combination drug therapy with an HIV vaccine. Other groups are exploiting the new discoveries about HIV receptors to engineer viruses that may selectively enter only HIV-infected cells and kill them—or at least disable the HIV.

There are drawbacks to combination therapy. Some patients cannot tolerate the regimen or the drugs themselves. Others have developed HIV that is resistant to treatment. This usually occurs because of lapses in the drug regimen, or because patients have added a protease inhibitor after developing virus that is resistant to two or three other drugs. But the biggest problem of all is money: triple-drug therapy costs from \$8,000 to \$12,000 a year, to say nothing of laboratory and doctors' bills.

If you're poor, you are unlikely to reap the benefits of the revolution in AIDS treatment. In the United States, women are left out disproportionately: they now make up 20 percent of Americans with AIDS, but they are less likely to be diagnosed and treated than gay men because they are more likely to be badly educated, drug-addicted, burdened with children, and poor. In the developing world, where the number of HIV-infected people is still skyrocketing, gender is not an issue. In countries where people are still dying in even huger numbers from illnesses that could be prevented by clean latrines, combination therapy for AIDS remains a remote prospect for men and women alike.

—Sarah Richardson

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Low-Flying Boom

FIFTY YEARS AFTER Chuck Yeager broke the sound barrier in the air, doing it on the ground might seem an anticlimax. After all, the “car” that did the deed last October in Black Rock Desert, Nevada, called Thrust SSC, is really a plane with clipped wings. Its two jet engines generate 110,000 horsepower—about a thousand times more than a Ford Escort—guzzle five gallons of fuel a second, and take about 30 seconds to get the 54-foot-long, seven-ton car up to supersonic speeds. Even the so-called driver, Andy Green, who clocked in at an average speed of 763 miles per hour over two runs, is a fighter pilot for Britain’s Royal Air Force.

But the engineering problems in getting a quasi plane not to take off are far from trivial. Air rushing over it creates lift, which forces it up even if it has no wings. The engineers had to compensate for that without grinding the car’s nose into the ground. And whereas shock waves on an airborne plane are free to spread out harmlessly in all directions, on Thrust SSC they hit the ground under the car—and its engineers couldn’t predict what repercussions that might have. “It’s a very peculiar problem,” says

Vroom, vroom—boom! Thrust SSC breaks the sound barrier without leaving the ground.

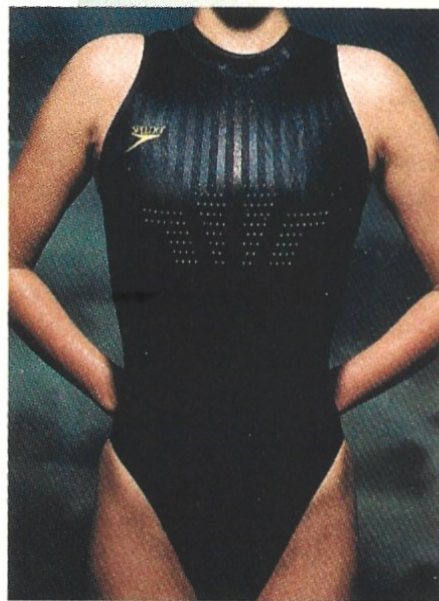


James Morton, design director of G Force, the British firm that built the car.

Yes, but what’s the point of solving it, given that supersonic cars would probably be a bad idea on the nation’s highways? The answer is: there is no point—except, perhaps, that some problems are fun to solve for solving’s sake.

—Fenella Saunders

DRAG BUSTERS A female swimmer looking for advantages over her competition might try getting in touch with Mizuno, the Japanese sporting goods manufacturer. More than just a fashion statement, that firm’s new swimsuit is a physics lesson—specifically, a lesson in drag, the frictional force that opposes an object’s motion. When the object is a female swimmer, a lot of the drag comes from her breasts: as water flows to the tip of the breasts and starts down the other side, it separates from the surface of the suit, creating big eddies, which absorb the swimmer’s momentum.



To get around that problem, engineers at Mizuno put 126 tiny silicone pins on the underside of the breasts. When water strikes the pins, it breaks up into many small eddies, which keep the water flowing closer to the swimmer, reducing drag. Mizuno engineers took a page from their counterparts in aerospace, who sometimes place protrusions on airplane wings.

Mizuno says its suit has 16 percent less drag than ordinary beachwear. The first suits were sold in Japan last February. Although Mizuno hasn’t put the suit on the American market, it has given samples to competitive swimmers.

—Lybi Ma

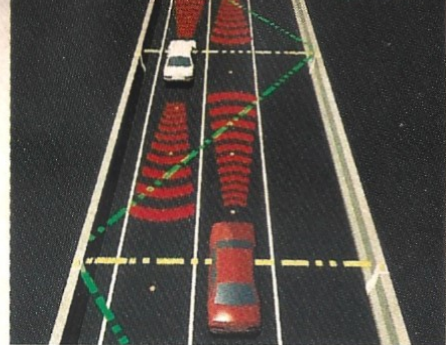
Look, Ma

THE TWENTY-FIRST CENTURY came early to a 7.6-mile stretch along Interstate 15 north of San Diego. One morning last August, several cars and a bus sped down the freeway in a tight line, like boxcars on a train, with only a few feet between each pair of bumpers. Even as the vehicles changed lanes and swerved past obstacles in concert, the drivers had little to do but watch the scenery.

Although this scene won't be coming to a highway near you soon, the technology may someday give our cars the wherewithal to drive themselves. The National Automated Highway System Consortium—which includes General Motors, Carnegie Mellon, and the Cali-

fornia Department of Transportation—with \$160 million from the U.S. Department of Transportation, is developing a host of new technologies. They include an "adaptive" cruise control that senses the speed of the car in front and adjusts accordingly, a system that allows vehicles to communicate their intentions to one another, and two schemes for keeping cars in their lanes—one with magnets embedded in the highway, and another with cameras that can see road lines.

The group still hasn't perfected the cameras, but researchers are confident they can overcome this hurdle. "Although there are still things we can't do very well, the individual technologies are



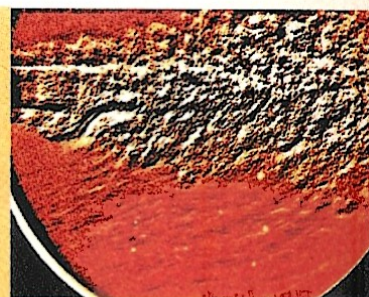
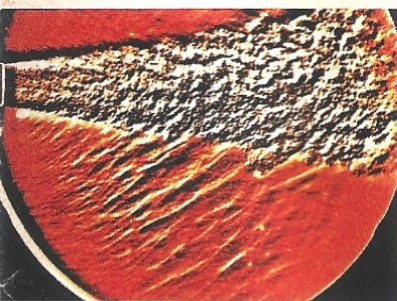
Someday the designated driver will be your car.

mostly straightforward," says Jim Rillings, a General Motors engineer and the consortium's manager. The tested vehicles managed to go 10,000 miles among them without incident.

Automating the highway would decrease congestion and increase safety, Rillings says. "Computers never get sleepy, never get distracted, and never drink too much." —Robert Pool

SUPPRESSED ROAR Supersonic jets aren't just noisy when they boom through the sound barrier. Even at takeoff, the fuel exhaust shoots out the back at supersonic speeds, and when it hits the surrounding air, it creates shock waves that make a fearsome racket. Last January aeronautical engineer Dimitri Papamoschou of the University of California at Irvine received a patent on a scheme to muzzle supersonic jet engines.

The key, Papamoschou realized, was to do something about the turbulent eddies that build up around supersonic exhaust (left). "Each little eddy behaves like a bullet," he says. "Since they move at supersonic speeds, shock waves form around them."



Papamoschou's idea is to create a cone of slower-moving hot air surrounding the exhaust that acts as a buffer between the exhaust and the ambient air. In his scheme, air expelled from the engine's fan is sped up with additional fans and then pumped out around the exhaust pipe. Since no volume of air moves against another at speed, shock waves never form (right). In tests on scale models, the air shroud cut engine noise by about 90 percent. —Fenella Saunders

Flying Doughnut

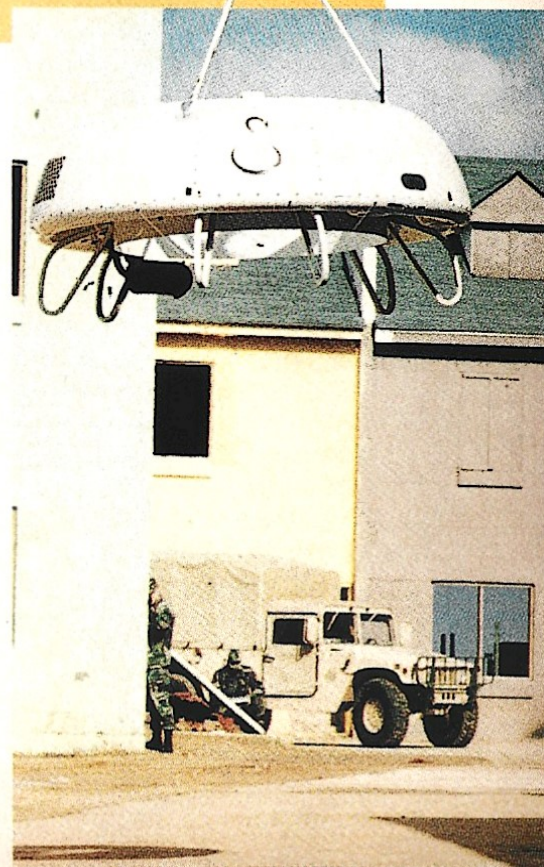
IT MAY BE a white disk hovering in the sky, but it's not a UFO. It's a flying robot called Cypher, and in its first full-scale test last January, it went gliding down the streets of Fort Benning, Georgia, peering around corners, hovering in front of windows, and perching on roofs.

Cypher is a six-foot-wide, 250-pound doughnut, with a pair of propellers in its middle. The propellers spin in opposite directions to cancel each other's torque—otherwise the contraption would twist out of control—but the blades are pitched so that both provide upward and forward thrust. The robot has a computer smart enough to follow commands like "fly down Main Street" without having to be told to avoid each lamppost, and a Global Positioning System receiver keeps it from getting lost.

The U.S. Army is considering using Cypher chiefly as a military scout. It can track a person through woods, scan an area for underground bunkers, or transmit battlefield images back to base. "The way we look at it is, Cypher is really a flying truck," says James Cycon, aerospace engineer at Sikorsky Aircraft Corporation in Stratford, Connecticut, which developed the robot. "We can put different instruments on it for whatever we want to do with it."

—Fenella Saunders

Cypher rises to the nation's defense.



My Five-Year-Old Could Do That

IT HAD BEEN several decades since physicists Neil Gershenfeld of MIT and Isaac Chuang of Los Alamos National Laboratory last felt such a powerful sense of accomplishment simply by adding two

numbers. Of course, they didn't do it the easy way, with pencil and paper—they did it by inventing a quantum computer. Last March they demonstrated the first

such device capable of adding one plus one, and by year's end they had it picking a telephone number out of a list of four. That's a far cry from the Pentium, but it's an important first step. In theory, quantum computers may one day far surpass conventional computers for certain applications.

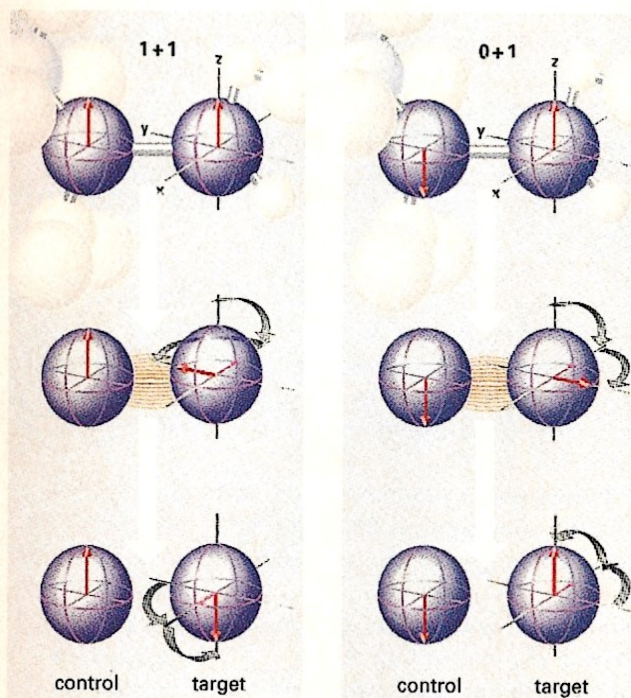
Whereas present-day computers represent data as a series of ones or zeros that correspond to electrical charges held in electronic circuits, quantum computers would use particles such as atoms instead of circuits, and they would use the atoms' quantum states to represent data. The main challenge in building such a device is to "read" the data and manipulate it without disturbing the delicate quantum states of the atoms. To get around this problem, Gershenfeld and Chuang

took atoms embedded in large, complicated molecules and used the direction of their spins to represent data. Not only is spin a much harder quantum state than the ones used by other physicists, but it also allowed them to use a proven technology—nuclear magnetic resonance machines—to read and manipulate the data. NMR machines use magnetic fields and radio waves to probe the spins of atoms and to change their orientation.

The heart of the two physicists' computer is a thimbleful of the organic chemical alanine. The trillions and trillions of atoms in that thimble point every which way, but a tiny plurality of them can usually be found pointing in one specific direction. These atoms, which stand out to the NMR machine because the spins of the other, randomly pointing atoms cancel one another, constitute one quantum bit, or qubit. The alanine molecule, it turns out, yields three qubits because it has three atoms of carbon that each responds to a different NMR frequency, and yet the atoms are still linked in such a way that they can be used for addition.

The physicists used just two of the carbon atoms, though, to add one plus one. The atoms were the quantum computer's hardware; its software program was the radio pulses the researchers nudged the atoms with. Each pulse made one atom in the pair (the "target") shift the orientation of its spin, in a way that depended both on the duration of the pulse—say, one-hundredth of a second for a quarter turn—and on the orientation of the partner atom (the "control"). When the program was finished, the final spin state of the atoms gave the answer—two, in this case.

The great potential of quantum com-

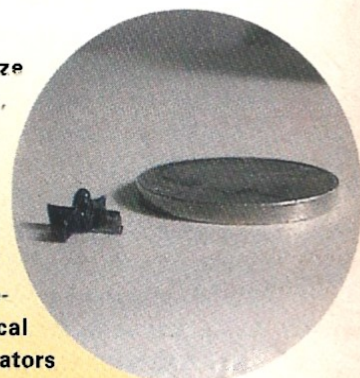


Adding qubits: To start, each atom's spin arrow (red) points up (for one) or down (zero). Next, radio pulses rotate the target atom clockwise or counterclockwise in three planes—and which way depends at a key step (middle) on the orientation of the control atom. Hence the two answers: binary 10 (two) and 01 (one).

THE WORLD'S SMALLEST PADDLE-WHEEL It was unveiled this past year by Masahiro Ota and his fellow mechanical engineers at Tokyo Metropolitan University. It has four aluminum blades, each a millimeter long and as thin as a piece of paper. When a precisely focused laser beam strikes the silicon-coated surface of one of the blades, the surface gets hot and heats the air on that side. The hot air expands—what there is of it; this all takes place in a near-vacuum—and pushes the blade from hot to cold, causing the rotor to spin away from the laser beam. At least that's what Ota thinks is happening. "I can explain the physical process behind how the rotor works, but not completely," he says.

Ota has gotten his rotor to turn 12 times a second, but he is now trying to sandwich insulation between the front

and back of the blades to maximize the difference in temperature, which would make the rotor turn faster. Within a few years he hopes to have made a rotor about a thousandth the size of the current one—that is, about the size of a bacterium. What would such a device be good for? "Opto-mechanical switches, gas molecular flow generators with a constant velocity and direction for depositing a thin film, and vacuum gauges," says Ota. The first item on the list means the rotor might one day find a home in an optical computer. But even now, without application, it's a neat little gizmo. —Fenella Saunders



Left: Ian Worppole; right: courtesy Masahiro Ota

puters lies in their theoretical ability to perform lots of calculations at once, which stems from the fact that atoms, according to quantum mechanics, exist in an infinite number of states until they are measured. Before they can tap this po-

tential, however, Gershenfeld and Chuang need to find molecules that will give them more than three qubits. With ten qubits, Chuang says, they should be able to do some simple factoring—figuring out, for instance, that 3 times 5 is 15.

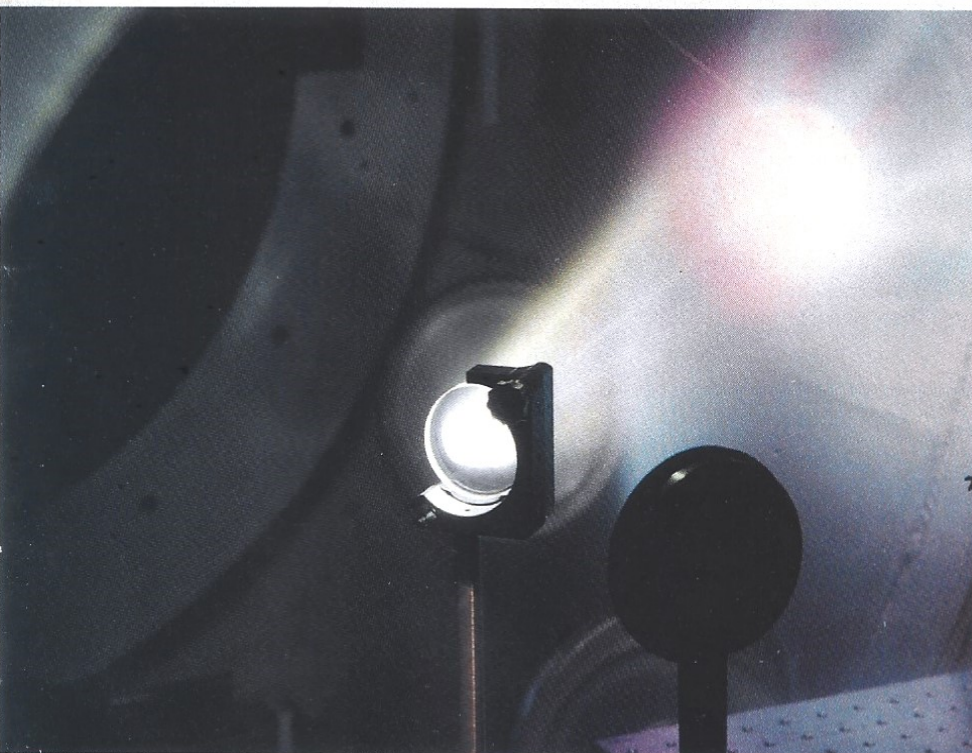
To do something really useful—to factor numbers large enough to crack encryption codes, for instance—“one would need thousands if not hundreds of thousands of quantum bits,” says Chuang. “That’s a ways off.” —Jeffrey Winters

THE PICOSECOND MIRROR For his work on nuclear fusion, physicist Michael Perry has built a very large laser. Its beam packs a million billion watts—1,000 times the power output of the entire United States. Of

course, it lasts only a trillionth of a second, which is why cities around the country don’t go dark when he does his experiments. But short as the blast is, it is intense enough to obliterate lenses and mirrors used to focus the beam. What’s a physicist to do?

Last May, Perry and his colleagues at Lawrence Livermore National Laboratory in California announced that they had solved the problem: they built a mirror out of hot electrically charged gas, also known as plasma. They start by shining the laser beam onto a small sheet of quartz. The laser vaporizes a thin layer of the quartz, which forms a cloud of plasma about the size of a half-dollar. Once the plasma attains a critical density of electrons, it becomes highly reflective. “Plasmas have always been sort of tenuous, fuzzy things, like the corona of the sun,” says Perry. “But if you have a plasma with an abrupt interface to air, it will behave the same way as a metal mirror.” This particular mirror dissipates within two-trillionths of a second, but by then the even shorter laser pulse has already done its job and the little pellet of nuclear fuel has been ignited.

—Fenella Saunders



Onward and Upward With Chips

dioxide, changing its electrical properties and thus corrupting the chip. So instead the early engineers used aluminum, a so-so conductor with well-behaved molecules.

By the late 1990s, however, with a hundred million transistors now regularly being crammed into an area the size of a contact lens, that decision is proving to be an intolerable nuisance. Whereas the average transistor has shrunk to a length

ENGINEERS HAVE SPENT the last few decades shrinking more and more electronic circuits onto semiconductor chips. Judging from the proliferation of gadgets and personal computers, they’ve done a pretty good job. But they all know that the party can’t last, that sooner or later they’re going to reach some kind of limit—though exactly what that will be, nobody really knows. Two advances reported this past year promise to postpone the day of reckoning.

First, researchers made an improvement in the way in which they interconnect transistors, the basic components of

most electric circuits, and to do so they delved into ancient transistor history. Back in the 1950s, when engineers first began putting more than one transistor on a single silicon chip, they tried to connect the transistors with tiny copper wires, which of course are excellent conductors. But copper atoms have the nasty habit of diffusing into adjacent layers of silicon

of a couple of millionths of an inch, the aluminum wiring has to be ten times thicker to carry enough electric current. Last September, researchers at IBM’s

A copper-wired chip on a stack of coppers.



Thomas J. Watson research labs in Yorktown, New York, put the finishing touches on a new technique that will let chip makers use copper after all.

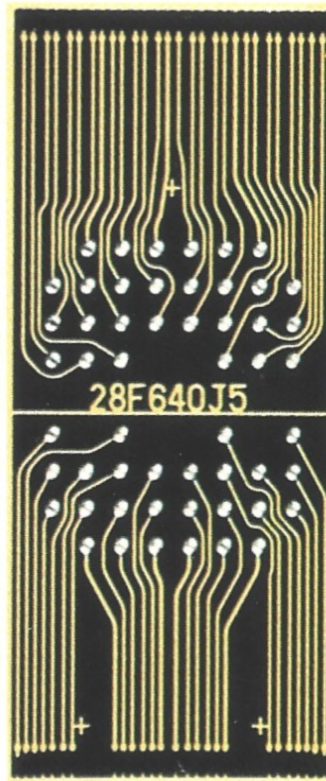
First the researchers make a layer of insulating material and dig trenches in it where they want the wires to go. Then, before they fill the trenches with copper, they lay down an ultrathin coating of some kind of metal—IBM isn't saying which—that keeps the copper atoms in place. The coating itself is a reasonable conductor, and since it is thin, it doesn't take much room away from the copper.

IBM says it can now use copper for all the wiring on a chip, replacing not just aluminum but also the tungsten that is now preferred for connecting different chip layers. The use of a single wiring material should simplify manufacturing and drive down the cost of chips. "We're not just changing one thing here," says Tom Theis, a physicist and leader of the IBM team. "We're changing everything about the way the industry makes interconnections in chips—the materials, the process—and we've had to figure out all the tricks to make all this work together."

IBM expects to roll out its first chips made with copper wiring in 1998.

The other advance, also announced in September, came from the Intel Corporation. Engineers there reported they had come up with a new method for reducing by half the number of transistors it takes to make a "bit"—one unit of binary memory. A bit is represented as an electric charge in a transistor; if a charge is absent, the bit is a zero, and if a charge is present, it is a one. Intel has devised a way of determining whether a transistor is a quarter, half, three-quarters, or fully charged—four different states, in other words, which means a single

This chip will make gadgets smarter.



transistor can now hold two bits of information. (The four states will correspond to 00, 01, 10, and 11.) For now the advance applies only to flash memories—the kind that retain information even when the power is turned off, like the ones in cell phones that remember your caller ID. But the impact of the advance should be widely felt in the next year or two in gadgets of all sorts, as bigger and cheaper flash memories make their way into digital cameras and answering machines as well as cell phones.

But the real news is—nothing much will change. "People will notice that things are continuing on the present course," says Theis, "which is very rapid progress."

—Fred Guterl

BEING THERE (AND EVERYWHERE)

Don't confuse it with virtual reality, that now-ancient technology for implanting yourself in a computer-generated world.

This is yet another leap in machine-made entertainment. Computer

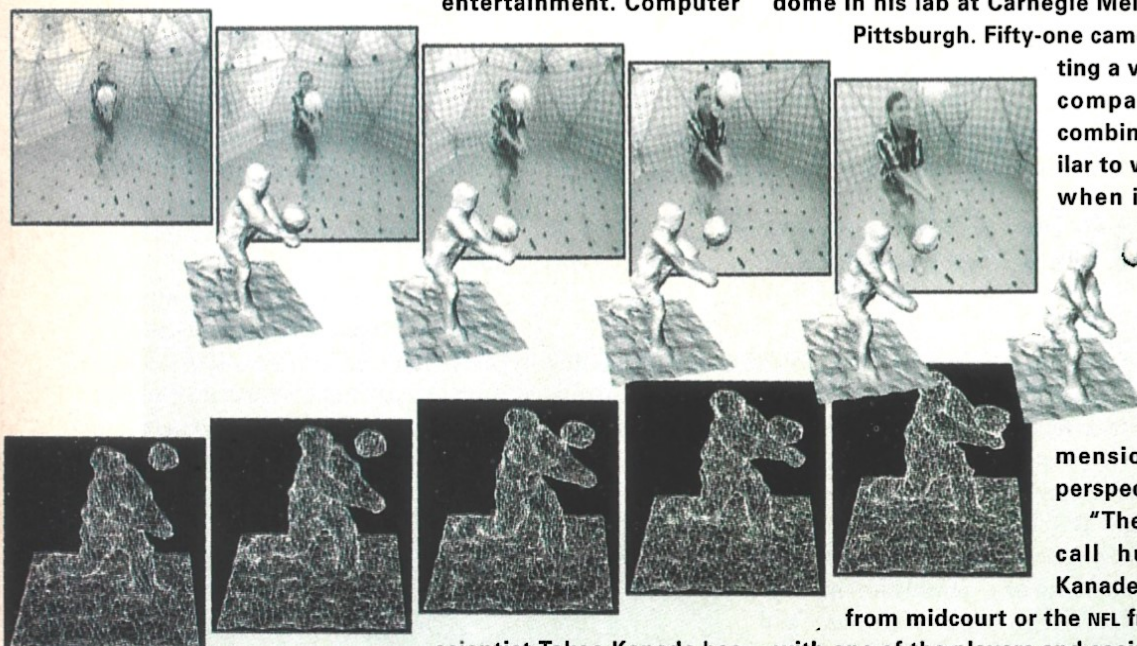
ball—all from the wreckage of your very own home.

Kanade calls his technology "virtualized reality," a name that seems unlikely to stick, and although he hasn't yet taken it to the court, he has demonstrated it in a 16-foot dome in his lab at Carnegie Mellon's Robotics Institute in Pittsburgh. Fifty-one cameras videotaped a man hitting a volleyball. Then a computer compared all these images and combined them, in a process similar to what the human brain does when it combines images from

two eyes. Since nothing save the soles of the player's shoes escaped the eyes of all 51 cameras, the computer had all the information it needed to generate a two-dimensional view from any given perspective.

"The eventual goal is what we call human transport," says Kanade. "We could watch the NBA from midcourt or the NFL from the field, even moving with one of the players and seeing what he saw." For now, however, it takes two days for his computer workstation to crank out a mere ten seconds' worth of images—and they aren't even as clear as television. Kanade hopes to bring out a TV-quality, 30-second "movie" in early 1998.

—Robert Pool



scientist Takeo Kanade has developed a technique for giving the motion picture viewer a choice of almost any perspective on the action. Someday soon, he warns, you'll be able to watch a game of basketball or volleyball from the bleachers, from beneath the net, or even from the point of view of the

from midcourt or the NFL from the field, even moving with one of the players and seeing what he saw." For now, however, it takes two days for his computer workstation to crank out a mere ten seconds' worth of images—and they aren't even as clear as television. Kanade hopes to bring out a TV-quality, 30-second "movie" in early 1998.

—Robert Pool

The Wreck Route

THE TRICK to finding untold sunken treasure may be to explore familiar spots where no one's thought to look before. That's what worked for Bob Ballard, anyway. Ballard, a former Woods Hole oceanographer, now heads his own Institute for Exploration in Mystic, Con-

Ballard, who had previously tracked down the *Titanic* and the *Bismarck*, realized that the deep sea, his specialty, had been overlooked in the study of antiquity. Archeologists had assumed that ancient mariners feared deep water. They figured that trading ships bound for Rome from

maybe this prediction was a self-fulfilling prophecy," says Ballard. "If you only look in shallow water, you're only going to find the wrecks in shallow water. It's somewhat like the drunk looking for his car keys under the lamppost because that's where the light is. The ancient mariner certainly knew the straight route. The question was, would he take it? He's an entrepreneur, he's a capitalist, and so a quicker route means fresher fruit, or certainly a better return on the investment. So I decided to search on that line."

In June, 80 miles northwest of Sicily's western tip and at a depth of 2,500 feet,



Full fathom four hundred and seventeen lie a household jug (left) and storage vessels (above) that may once have held fish sauce.

necticut. Using a nuclear submarine this past year, he and his team scoured an unexplored area of the Mediterranean seafloor and discovered a graveyard of eight ships, including one of the earliest known from the Roman era.

Carthage, in what is now Tunisia, would make the short crossing to Sicily or Sardinia and hug the coastline the rest of the way. The third route, cutting straight across the Tyrrhenian Sea, would be the least likely place to find ships. "I thought

the Navy's NR-1 research submarine, equipped with a powerful sonar designed to hunt Soviet subs under Arctic ice, started finding ships over 20 square miles of seafloor. "They found ships almost every other day," says Ballard. "We had to tell them to stop, because they were finding them faster than we could follow up with the mapping exercises." These boats weren't smashed by rocks, like shallow shipwrecks. They had simply succumbed to the waves that washed over their decks

during storms, sunk slowly to the bottom, and landed gently on the seafloor, where mud gradually covered them. While marine organisms nibbled away at any fleshy remains, and tiny wood-boring insects ate sails and wood uncovered by mud, some of the ships' cargo and buried timbers remained undisturbed. "It's just sitting there," says Ballard. "Which is sort of amazing, that it's been waiting around for two millennia. You come in on it, and it's like 'Well, finally, someone's found us. Where ya been?'"

Five of the eight ships (which were

identified by their cargo) came from the Roman era, from the last century B.C. and the first few centuries A.D. Another was a medieval Islamic vessel carrying glass lamps used in mosques, and the other two were from the nineteenth century. Using *Jason*, a remote-controlled submersible, Ballard retrieved timbers; copper and bronze pots; terra-cotta amphorae and jars, which probably carried things like wine, oil, preserved fruit, or sauce made from fish, a popular relish; and even delicate glass lamps. One Roman ship carried huge blocks and columns of gran-

ite, of the sort used in building temples.

The granite blocks, of course, had to remain in the deep, as did the bulk of the ships' cargo. This expedition wasn't geared toward excavation, says Ballard. Though other wrecks certainly lie along this well-traveled route, he plans to move on to the eastern Mediterranean next, while archeologists ponder the objects he has retrieved. "I think the deep sea may contain more history than in all the museums of the world combined," he says. "I think we're just discovering the pyramids of the deep."

—Shanti Menon

OLD MACDONALD HAD A HENGE Modern-day druids, who flock to Stonehenge each summer solstice, may be disappointed by the discovery of the oldest henge in Britain. At 5,800 years old, the Coupland Henge in Northumberland is 800 years older than that mystical site—and it was probably a cattle corral.

Henges are circular structures formed by an inner ditch and surrounded by an outer earthen mound, with one or two entrances. Although they vary in details—some, like Stonehenge, have standing stones inside, usually a later addition—archeologists have pretty much agreed that all henges were ceremonial centers and probably date back at most to 3000 B.C. But archeologist Clive Waddington of Durham and Newcastle Universities published a booklet last April suggesting that Coupland Henge is different.

Coupland Henge is more than 300 feet in diameter and

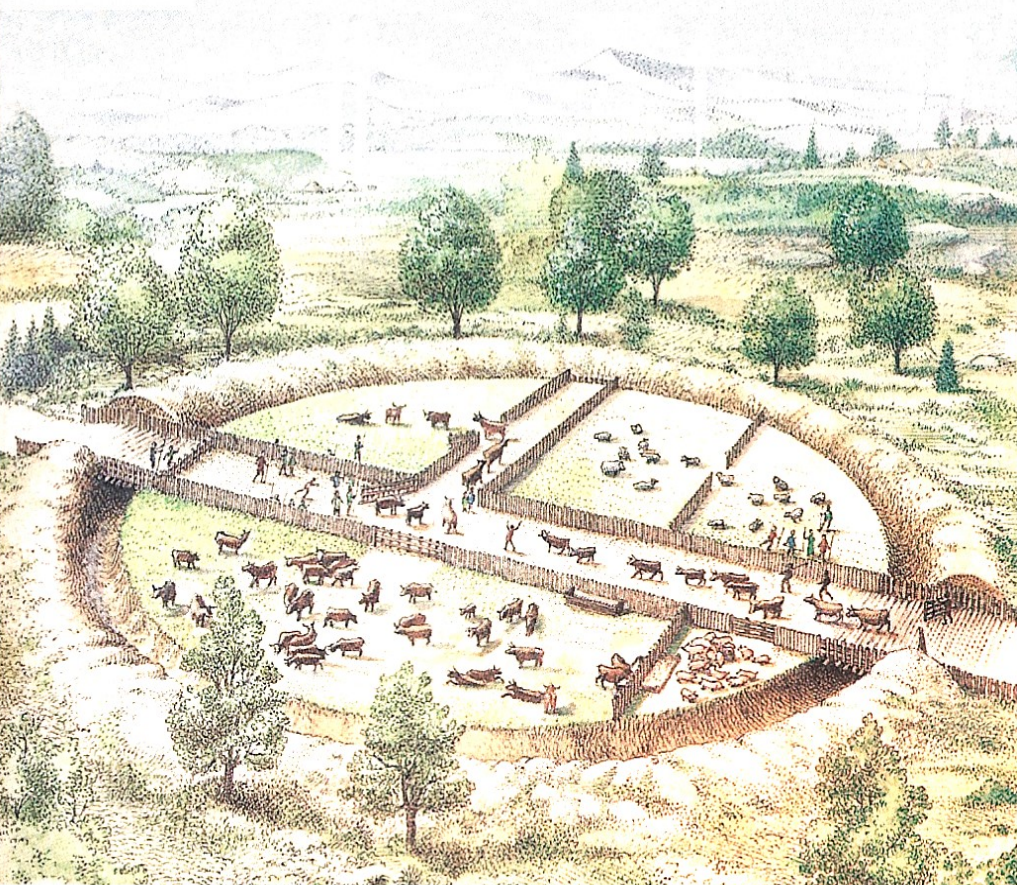
is bisected by two linear ditches that connect entrances on opposite sides of the henge. In the center of the ring, Waddington excavated bits of pottery, flint and agate tools, and charred hazelnut shells. These objects overlay a bed of charcoal, which yielded a radiocarbon date of 3800 B.C. or even earlier. That pushes the henge tradition back almost 1,000 years.

At the circle's northern entrance, on either side of the ditches, Waddington found two holes lined with stones that he thinks held gateposts. Stains in the soil suggest that the ditches held a wooden-plank fence as well. The ditches extend about half a mile north from the enclosure, in the heart of the region's main settlement area, to a ford on the River Till. Pollen analyses showed that the uplands on the far side of the river were once open woodland, the natural habitat of browsing pigs and cattle. "That land was useless agriculturally," he says. "The most productive use to which it could be put was stock grazing."

Waddington thinks the ditches are what's left of a fenced-in drove way through which cattle were herded into the enclosure after being brought across the river. The fences kept them from trampling crops in the settlement area. The henge may have had religious significance as well. "They were using the fells"—the upland pastures across the river—"for summer grazing, then driving them down to this lowland enclosure for overwintering," says Waddington. "There were probably rituals associated with these transitions from one phase of the year to another."

While Stonehenge itself might not have been a corral, Waddington thinks Coupland probably better reflects the original purpose of henges. "Over time, the functional uses of these monuments degenerated," he says. "They used that form and reworked it into something purely religious."

—Shanti Menon



Blackbeard's Ship

THE TRAVELER'S TALE Every one loves a good yarn, and Shakespeare was no exception. The bard is said to have based *The Tempest*, which he wrote in 1611 or 1612, on an account of a 1609 shipwreck in Bermuda. This past year, archeologists in Jamestown, Virginia, announced that they had turned up a signet ring bearing the splayed-eagle family crest of the unlucky adventurer who wrote that account.

William Strachey, a 37-year-old English gentleman and former ambassador to Turkey, was heading for the newly founded Jamestown colony when a hurricane wrecked his ship off Bermuda, explains William Kelso, director of archeology for the Association for the Preservation of Virginia Antiquities in Richmond. Some of the crew and passengers, including John Rolfe (Pocahontas's future husband), made it to shore. They spent the next year on the uninhabited island building another ship, which carried them at last to Jamestown.

Once there, Strachey sent several lengthy letters about his adventures to England. His tale of shipwreck and island living was devoured by curious Londoners, and literary historians are confident that Shakespeare, a voracious reader, was among them, right before he wrote *The Tempest*. Not only is the story line similar but so are the islands: Shakespeare's "Though this island seem to be a desert" echoes Strachey's "Sure it is that there are no rivers nor running springs of fresh water to be found upon any of them [the Bermudas]."

Strachey returned to England in 1611. His ring, which was found next to a gunpowder storage pit, is the first of some 100,000 Jamestown artifacts to be linked to a specific individual. But its real significance, says Kelso, is that it places the English settlement of America in a vivid historical context. "It shows we've got a history quite a few years before Jefferson, Washington, and those guys. It goes back to Shakespeare at the height of his career."

—Sarah Richardson

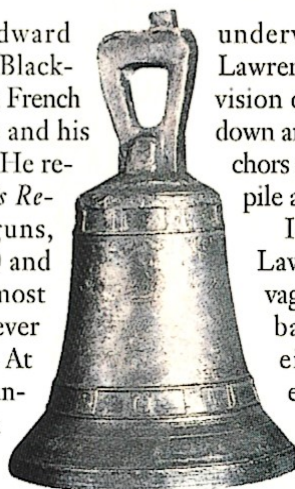
IN NOVEMBER 1717, Edward Teach, best known as Blackbeard, took command of a French merchant vessel that he and his shipmates had captured. He renamed her *Queen Anne's Revenge* and added 20 guns, bringing her total to 40 and making her one of the most formidable pirate ships ever to sail the Spanish Main. At her helm, Blackbeard plundered at least 18 ships in seven months, 8 or 9 of them during a notorious weeklong blockade of Charleston. In June 1718, days after the blockade ended, *Queen Anne's Revenge* ran aground at Beaufort Inlet, North Carolina. Blackbeard escaped with the loot.

That hasn't stopped archeologists from looking for his ship, though, and

underwater archeologist Richard Lawrence of the North Carolina Division of Archives and History dove down and had a look. "There were anchors and cannons just sitting in a big pile at the bottom," he says.

In a series of dives in 1997, Lawrence and his colleagues salvaged a few artifacts, including the barrel of a blunderbuss—the eighteenth-century pirate's equivalent of a sawed-off shotgun. A bronze bell bearing the date 1709 assured them that they were in the right time period, and a 24-pound cannonball that they had the right sort of ship: only a large one—the *Queen Anne's Revenge* was 103 feet long, had three masts, and carried 150 pirates—could handle guns that big. How much of the ship itself remains is still in doubt. Lawrence thinks he spotted a couple of the ships' ribs, "but we really need to follow them out to see if the bottom hull is still intact," he says. "My guess is that we will find a good bit of it still there."

—Shanti Menon



Blackbeard's bell (top), blunderbuss barrel (above, shown with a complete gun), and the pirate himself (right).

this past year one group announced they were 90 percent sure they'd found it. Intersal Inc., a Florida-based marine research and recovery firm, used a magnetometer to scan the seafloor in Beaufort Inlet for anomalies caused by iron or steel. On November 21, 1996, the surveyors spotted something in 20 feet of water. The next day, the 278th anniversary of Blackbeard's death (just five months after his escape, he was hunted down and decapitated by the British Navy, and his head was fixed to a bowsprit),



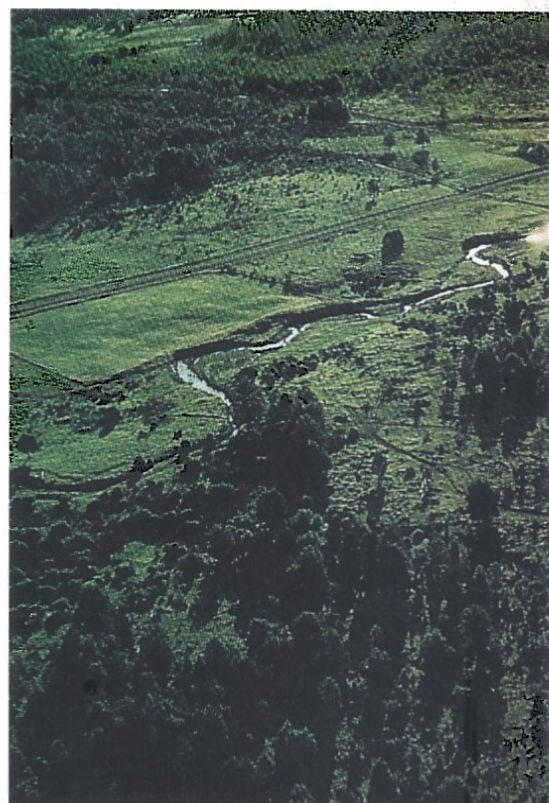
Clovis R.I.P.

AT A BAR in the Chilean town of Peluco last January, a dozen archeologists toasted the passing of a paradigm. They had finally accepted that the nearby site of Monte Verde was 12,500 years old. In doing so they put to rest the long-standing theory that the first Americans were the Clovis people, big-game hunters who came from northeast Asia, and whose distinctive 11,500-year-old stone spear points were first found near Clovis, New Mexico.

University of Kentucky archeologist Tom Dillehay has been working at Monte Verde, 600 miles south of San-

few yards away from the 12,500-year-olds might be a shocking 33,000 years old—which he still thinks, although he says the evidence is “inconclusive.”

But the evidence that people were living at Monte Verde at least a thousand years before Clovis, Dillehay says, is airtight. On the banks of Chinchihuapi Creek, he has found a campsite that was occupied by a small band of hunter-gatherers for about a year until it was flooded by the creek. Layers of peat grew over the material they left behind, shutting out oxygen and preserving things like mastodon meat, wooden lances, planks



Monte Verde (above), near Chinchihuapi Creek; mastodon ribs (below), useful for cooking.



A large stone, perhaps once part of a bola, with a modern sling and a replica stone shot.

tiago, for 20 years. “We didn’t set out to question Clovis,” he says. “We were just doing local research.” His initial announcement about the site, over a decade ago, was met with immense skepticism. The Bering land bridge was the obvious point of entry into the New World—aside from a trail of Clovis points, linguistic and genetic evidence also pointed to a northeast Asian origin for Native Americans—but massive ice sheets blocked that route, it seemed, until after 13,000 years ago. And it didn’t help convince people when Dillehay began saying that artifacts a

and stakes, knotted reeds, animal hide, and chewed plant leaves. The wooden planks and stakes formed the frame of a large tent, once draped with mastodon hides and divided internally by more flaps of hide. Perhaps 20 to 30 people lived in it.

They were adept foragers, not afraid of traveling 30 miles to the Pacific shore to collect shellfish. They ate mushrooms, berries, nuts, and potatoes. They hunted mastodons and the ancestors of llamas with wooden spears and perhaps bolas—Dillehay has found heavy, spherical stones that look like the business end of a bola. They combed the beaches, bogs, and temperate rain forests, collecting novelties like colored pebbles, as well as important medicinal plants, some from

100 miles away. In another shelter, set apart from the main tent, Dillehay found a chewed-up wad of boldo, a plant now used to treat stomach pains. Near a fire-





place, someone—probably a child—had stepped into soft clay, leaving a tiny footprint.

After the first volume of Dillehay's report on Monte Verde was published in 1989, many archeologists believed the site was genuine. But it remained highly controversial, primarily because a small group of high-profile experts were unconvinced. They doubted that the artifacts he described were made by human hands. They thought his dating, based on radiocarbon ages from charcoal, wood, and ivory, showed too much variation and was somehow contaminated. Anyone who was going to claim a pre-Clovis site would have to go to extraordinary lengths to back it up. "The site was very unfamiliar in almost all its details of structure and content," explains Dena Dincauze, an archeologist at the University of Massachusetts at Amherst and one of the original skeptics. "It required that we revise our entire model of how people came into North America. So you want to be really sure about that before you overturn your own applecart."

"We kept saying, 'Put your money where your mouth is and look at the evidence,'" says Dillehay. Finally, this past year enough funds were raised to bring a small group to Chile, including some of the last Clovis holdouts. After seeing the artifacts, examining the different layers of sediment in the trenches, and reading the 1,300-page second volume of Dille-

CITY OF THE DEAD

In 332 B.C., Alexander the Great commanded that a city be built at the edge of the Nile delta. He never lived to see it, but within a century, Alexandria was the biggest city in the world, a cultural and intellectual center with a population of more than 400,000. To the west of this flourishing capital lay another splendid city. The Greek historian Strabo, who visited around 25 B.C., marveled at its luxurious gardens, its dining halls, its embalming houses. He called it Necropolis—the city of the dead. It had been built by the second century B.C. to accommodate Alexandria's growing number of corpses.

Modern Alexandria has long since overrun Necropolis, but last March archeologists got their first good look at it, when workers building a highway bridge uncovered the wall of a large tomb. Excavations led by archeologist Jean-Yves Empereur, head of the Center for Alexandrian Studies, revealed that the tomb extended downward at least 26 feet. Its walls were pitted with 150 loculi, cubbyholes in which bodies were laid to rest, usually more than one to a hole. Empereur has since uncovered 17 separate tombs, some connected by tunnels dug by grave robbers, in an area that covers about 40,000 square feet. He and his team were led through the maze by a six-year-old boy who had found his own entrance to the catacombs and familiarized himself with every gap and crevice he could fit through.

The grave robbers had left little of value, but Empereur was pleased to find a few carved sarcophagi, flasks of perfume, empty wine jugs, and intact funerary urns. Slabs of stone painted with floral and geometric designs, in imitation of a door to a house, covered some of the loculi. In one tomb, Empereur found a painting of a seated woman, about to descend to the underworld, saying goodbye to her husband.

The people entombed here were middle class, and at least in the earlier centuries, Greek. Five skeletons—of the hundreds the researchers have found—still carried coins in their mouths to pay Charon the ferryman for passage across the River Styx. Empereur and his team also found traces of a dining room, where families of the deceased would come to eat, drink, and pay their respects to the dead. Despite Strabo's mention of embalming houses, though, the team has not found any mummified bodies. On the other hand, they have found a few graves marked with Christian crosses. It seems Necropolis was used for close to 800 years, until about the fifth century A.D.

The construction of the highway has temporarily halted, and negotiations are under way to keep the excavation going. The researchers have hit groundwater, which they hope may have deterred grave robbers; Empereur thinks there may be intact burials in some of the lower levels. "Necropolis was huge, over one square kilometer," he says. "Until now we have excavated only one-fifth of the land to be covered by the bridge. We hope to find much more." —Shanti Menon

hay's report, published last spring, even the staunchest skeptic was converted. "I've signed off on it because there are six artifacts that are unequivocally artifacts," says archeologist and geologist C. Vance Haynes, Jr., at the University of Arizona in Tucson. "These are projectile points, a slate rod, and a grooved stone." Dincauze herself was sold by Dillehay's exhaustive analysis. She calls his monograph "a superb archeological presentation, completely convincing, and thoroughly documented. Everything the preliminary reports weren't."

The problem for archeologists now is explaining how people got to Monte Verde. The northern route is still the most likely—there's no evidence for a

transoceanic voyage. "People were in North America long before 12,500 years ago," says Dillehay. It must have taken them thousands of years to get as far as Monte Verde. They must have arrived before the ice sheets blocked off Canada 20,000 years ago; in fact, they must have arrived much earlier than that if they reached Monte Verde 33,000 years ago, which is what Dillehay suspects happened. Conceivably, people could have avoided the ice by traveling down the Pacific coast, staying along the waterways. "Right now, we're at the anything is possible point," says Dincauze. "It's opened everything up. Now we have to start picking up the apples again."

—Shanti Menon

The Jaws You Can't See

CONSIDER THE FOLLOWING movie pitch: An army of all-but-invisible one-celled creatures arises from the muddy bottom of an estuary to inflict hideous carnage. Although normally quiet and nontoxic, the beasts start releasing potent poisons into the water, paralyzing fish that happen to pass by and leaving them gasping for air. The poison also disrupts the internal salt balance of the fish in a matter of seconds so that they soon develop bleeding skin sores. The microscopic killers feast on the tissues sloughed off by the dying fish. Then they encase themselves in protective cysts and sink out of sight, leaving thousands of fish inexplicably dead.

Though it sounds like grade-B horror, the story could actually be made into a cold-sober documentary. This past summer on the coasts of North Carolina, Virginia, and Maryland, a tiny toxic organism with the singable name of *Pfiesteria piscicida* was implicated in large-scale fish kills and poisonings in nine rivers. All but unknown only a decade ago, it has been making a pest of itself in North Carolina waters in recent years, killing over a billion fish since 1991. In 1997 it turned into a regional crisis. Fearing a threat to public health, officials closed sections of three rivers that feed into the Chesapeake Bay—the Chicamocomico, Pocomoke, and Manokin—inciting near-panic in the fishing and tourism industries.

Pfiesteria is a mystery of biology. It is a species of dinoflagellate, a type of plankton that sits on an obscure branch of the evolutionary tree not far from amoebas and slime molds. Most dinoflagellates depend on photosynthesis for survival, but *Pfiesteria*, which passes through more than 20 radically different life stages, feeds on other organisms. No one can say for sure why it is emerging now, but prime suspects are the agricultural operations—particularly hog and chicken farms—that send nutrient-rich runoff into estuaries in quantities that

may far exceed the capacity of harmless plants in those ecosystems to absorb. “We have been pouring millions and million of tons of nutrients into these poorly flushed systems for years,” says JoAnn

These menhaden from Maryland were victims of *Pfiesteria*.

Burkholder, a North Carolina State University botanist who is leading the research on *Pfiesteria*. “Perhaps we were inadvertently doing an experiment and slowly shifted the balance in favor of these organisms going into toxic mode.”

The dangers from the poisons that *Pfiesteria* manufactures aren't limited to fish. Research has shown that *Pfiesteria* can kill shellfish such as crabs, oysters, clams, and scallops and may also harm marine mammals. People who have crossed paths with *Pfiesteria* have suffered memory loss and impaired cognitive skills. “We have to begin to take better care of our coastal areas not just for the sake of fish resources but for our own health as well,” advises Burkholder. “It isn't just a fish kill anymore.” —Catherine Dold



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Pollutants Are Androgynous

THE IDEA THAT pollutants may interfere with sex hormones has gotten a lot of press lately—stories of alligators and otters with shrunk penises have received wide publicity. In spite of these deformed male organs, most research has focused on estrogen, the female sex hormone: males make it, too, and besides its role in the female reproductive cycle, it carries crucial signals in developing embryos of both sexes. Just as vulnerable, though, are testosterone and other male

sex hormones—androgens, as they're called. This past year a Vanderbilt University School of Medicine study showed that androgens may actually be even more sensitive to interference than estrogen is.

Pesticide by-products, plastic components, red dye no. 3—a wide range of chemical compounds have been shown to bind to estrogen receptors inside cells and thereby block the hormone's signal. "The problem has been that until a few years ago everyone was considering these pollutants as strictly estrogenic," says Benjamin Danzo, a reproductive endocrinologist at Vanderbilt, "and had never given thought to the fact that they might also be androgenic."

For his study, Danzo gathered ten pollutants and put each one in a test tube

containing either estrogen or androgen. Each tube also contained one of four types of protein that bind estrogen or androgen (the two kinds of cell receptors and two other proteins that help move the hormones around the body). Danzo then compared how well the hormone and the pollutant bound to each protein. To his surprise, of the ten pollutants, five bound easily to the androgen receptors, while only two bound to the estrogen receptor. One pollutant—a by-product of the insecticide lindane—bound particularly well to a protein that helps move androgens along after they are secreted by the testes.

Danzo is now running experiments to see what effects these pollutants have on living guinea pigs. It's important to keep in mind that while pollutants may bind to hormone receptors and other proteins, natural hormones do so far more effectively. "But there are so many pollutants around," Danzo warns. "We're not exposed to one of them at any given time—we're exposed to large numbers of them."

—Sarah Richardson

Uncleared Air

ON A WEDNESDAY MORNING nearly 50 years ago, a heavy smog settled on the Pennsylvania town of Donora. At first, residents simply remarked on a few sore throats. By Friday, however, hundreds of people were seriously ill. By Sunday, 19 were dead.

Such smog disasters helped persuade the government to start controlling air

pollution. Federal laws were passed—most notably the 1970 Clean Air Act—and as a result many people now assume that death by smog is a thing of the past.

Not quite. Some pollutants are safely under control, but others are still killing, according to the Environmental Protec-

Still lethal after all these years?



tion Agency, which this past year proposed to tackle them. The worst are fine particulates—grit and chemicals that travel deep into the lungs. By aggravating heart and lung disease, says the EPA, fine particulates contribute to 60,000 deaths a year in the United States. Two large health studies reviewed by the agency found that residents of towns with high particulate levels were 17 to 26 percent more likely to die prematurely than were residents of cleaner towns.

The rules proposed by the EPA last July would regulate fine particulate emissions for the first time. They would also strengthen controls on ground-level ozone, which the EPA said causes hundreds of thousands of cases of respiratory illness each year. The EPA claimed the new rules would prevent 15,000 deaths, 350,000 cases of aggravated asthma, and a million cases of decreased lung function in children. The price would be \$9.7 billion a year for controls on diesel motor vehicles, power plants, and other sources.

Not surprisingly, the price seems too high to industry groups, which challenged the EPA's interpretation of the studies. "There is no credible basis to believe that the proposed standards [on particulates] will produce any measurable health benefits," said the American Petroleum Institute. As the year ended, the debate was unresolved, and Congress was considering bills to delay the EPA rules until more research is done. —Catherine Dold

NOT A PRETTY PICTURE Cholera. Plague. Typhoid. Beyond reading headlines in their morning papers, people in Western nations have little contact with these diseases, but in the developing world, where crowded cities often lack sewer systems, they are part of daily life. And the situation is getting worse. According to a report released this past summer by the United Nations Children's Fund (UNICEF), almost 3 billion people—about half the world's population—now live without clean toilets. More than 2 million children die each year from diarrhea-causing diseases, infected by bacteria that could easily have been avoided if they had been flushed down a pipe.

There's a grim irony to this crisis. At the same time that sanitation has been neglected, clean drinking water—a more politically powerful issue—has not. Over the past seven years, 800 million people have gained access to safe drinking water. During the same time, the number of people without access to clean sanitation rose by 300 million. "Sanitation is really more important than drinking water, in terms of the effect on human health," says John Bolland, an environmental economist at Johns Hopkins. "But drinking water is seen by governments as the number one priority. So that's where the economic assistance goes."

In a number of poor communities, residents are pooling their resources to build and maintain clean latrines, but it's doubtful whether such grassroots efforts can solve a crisis that affects 3 billion people. UNICEF estimates that providing sanitation systems worldwide would cost \$68 billion spread over ten years. Meanwhile, urbanization adds to the misery. Over the next 25 years, the populations of cities are predicted to swell by more than 10 percent—leaving that many more people to struggle with filth. —Kathryn Brown



The Value of the Free Lunch

TREATING WASTEWATER is expensive: to get rid of organic matter, phosphates, and nitrogen compounds that farms and cities release into rivers, you need to pump the water through costly complexes of pumps, filters, and tanks. A tidal marsh, on the other hand, does the same job free of charge. The polluted water fertilizes plants and microbes, which in turn support a huge food web, and by the time the water makes its way out of the marsh, it's scrubbed clean. One acre of tidal marsh performs about \$2,800 worth of water purification every

year. Multiply that by the 165 million acres of coastal wetlands on the planet, and you get a tidy annual bill of \$462 billion.

That sort of figure doesn't often make its way into environmental decisions, but Robert Costanza thinks it should. "Every time we do something that affects these ecosystems, we're making a trade-off, but we don't realize it," says Costanza, an ecological economist from the University of Maryland. Costanza is part of a growing movement of researchers who are trying to find the value of ecosys-

tems—including not only their commercial products, like forest timber, but also the less visible ways in which they make the planet habitable. Forests prevent soil erosion and mud slides that would be expensive to stop artificially; coral reefs not only act as nurseries for young fish but also help protect shorelines.

This year Costanza and a group of like-minded colleagues put together a rough estimate of the total value of the world's ecosystems. "This is a back-of-the-envelope calculation, but nobody had done it before," says Costanza. It's far from perfect—the researchers used values calculated from studies of a handful of swamps, for example, and applied them to all swamps worldwide. But when faced with uncertainty, they tried to stick to low-end figures. And still the total price was astounding: ecosystems, they



estimate, provide \$33 trillion dollars of services every year—which is \$8 trillion more than the gross national product of all the countries on Earth. “The assumption of a lot of economists

was that, yeah, there are these services, but they are probably pretty minor—maybe 1 or 2 percent of GNP, and so they don’t have to be a main focus,” says Costanza.

The map Costanza’s group created reveals that not all ecosystems are created equal. The services provided by forests and grasslands that make up much of the interior of the United States are worth about \$100 an acre. But coastal ecosystems—such as estuaries, tidal marshes, mangroves, sea-grass beds, and coral reefs—are much more pricey, running up to as much as \$8,000 or \$9,000 an acre a year. Although they make



up only 6.3 percent of the planet’s surface, they make up 43 percent of the value of its ecological services. “In ecology, the edges are where a lot of important things happen,” says Costanza. But sadly, these are some of the most endangered ecosystems of all, in part because over half the world’s population lives in coastal regions. We can’t count on tidal marshes to take care of our sewage anymore. At least now we have a better idea of the value of what we’re losing.

—Carl Zimmer

IODINE WIND The National Cancer Institute revealed this past fall that as many as 75,000 Americans were exposed to radioactive fallout from bomb tests in the 1950s and 1960s at levels high enough to cause thyroid cancer. Each of the 90 aboveground tests in Nevada sent clouds of radioactive iodine (I-131) and strontium (S-90) into the sky. In the weeks following each test, the drifting chemical haze settled as dry particles or rain across the country, especially in the states immediately downwind: Colorado, Idaho, Montana, South Dakota, and Utah.

Scientists worry most about those who grew up on farms in those states. When cows graze on grass doused with I-131, the chemical enters their milk. Children under six, who have small thyroid glands and consume lots of milk, received three to seven times higher doses of I-131 than adults did, according to the NCI—and they were especially likely to get a high dose if they drank milk from a family cow. I-131 has a half-life of only eight days, which means that milk that was shipped to a dairy and then to the grocery store had enough time for most of the radioactivity to fade. “But if you’re living on a farm, the milk from your backyard cow may be just 12 hours old when you drink it,” says Joseph Lyon, an epidemiologist at the University of Utah in Salt Lake

City. “That fresh milk still has a lot of radioactivity in it.”

Kids who grew up during the Nevada bomb test years are just now entering their fifties, an age at which cancer rates skyrocket. Estimates of the number of thyroid cancers caused by the tests range anywhere from 10,000 to 75,000, of which perhaps 30 percent, according to the NCI, have already been diagnosed. When detected early, the disease can usually be cured.

—Kathryn Brown



Your Stars for 1998



Knowing more about the skies than our forerunners doesn't improve our view.

BY BOB BERMAN

WE COMMONLY USE two methods to interface with the sky. The first, and most ancient, is simply to look up. This works well if the weather's clear and some celestial event is actually taking place. The second is to slouch into an easy chair and read about the newest discoveries and celestial happenings. That's what you're doing right now—and what you'll be doing for most of 1998.

The reason is that the coming year offers remarkably few predictable events, at least glitzy ones. Not one total lunar or solar eclipse will be visible from anywhere in the United States. The year's premier meteor showers, the Perseids of August and the Geminids of December, will both be washed out by nearly

full moons. A subdued Mars will fail to reach any close approach. Twelve months ago we awaited the arrival of comet Hale-Bopp; this year we know of no bright comets that will rendezvous with Earth.

Not all is bleak, however. Among the planets, Jupiter and Saturn will do reasonably well, at the start and near the close of 1998. They're nice right now (but sinking into the west); then they'll vanish from convenient viewing for much of the year before reemerging for closest approaches in early autumn, when both will be higher and brighter than any time this decade.

The year has another bright side: the sun. After bottoming out two years ago in the solar storm department, the sun is coming on strong as we head toward the predicted sunspot maximum in the year 2000. With any inexpensive sun filter (like shade number 14 welder's goggles), you'll start seeing naked-eye spots on our nearest star. (If you live in the southern states, use that filter for the partial eclipse of February 26.) Because of those storms, sky watchers in the northern half of the country who live away from city lights will have their best opportunity in years to see the aurora borealis.

This year's relative desperation also makes it a good time to focus on lesser known phenomena. For example, the leisurely, loping Quadrantid meteors, normally the year's third or fourth best shower, occur under dark, moonless conditions on January 3, while the ultrafast Leonids may put on a spectacle on the nights of November 17 and 18. Don't hold your breath for that one, though—the Leonids are only impressive once every 33 years, and next year has the better shot.

The coming months do offer several nice conjunctions. My pick is on the morning of April 23, when Venus and Jupiter, the night's two brightest "stars," nearly touch each other, with the waning crescent moon floating nearby.

A more convenient conjunction—in the southwest right after sunset—is under way now. An extremely tight meeting of dazzling Venus and little Mars unfolds on December 21 and 22. New Year's Day finds bright Jupiter and the crescent moon aligned at that same time and place.

Telescope owners can now drag out their scopes before dinnertime to watch Jupiter, Saturn, and Venus in the southwest. Venus is especially dazzling as it plunges lower into twilight each evening. Our nearest planetary neighbor passes between us and the sun at midmonth, vanishes for a week or so (to all but careful observers), and then reemerges like a phoenix just before sunrise in late January.

We'll let Venus, that symbol of love, open this challenging year on a mushy optimistic note. But the great thing about the sky show is that you never know when a sudden aurora, a fantastic comet, or an exploding meteor will visit. What starts as a nothing-much 1998 might yet make the history books. ☐

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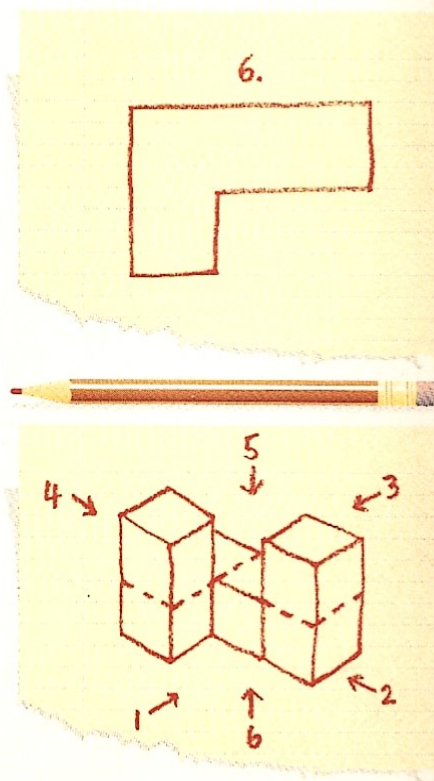
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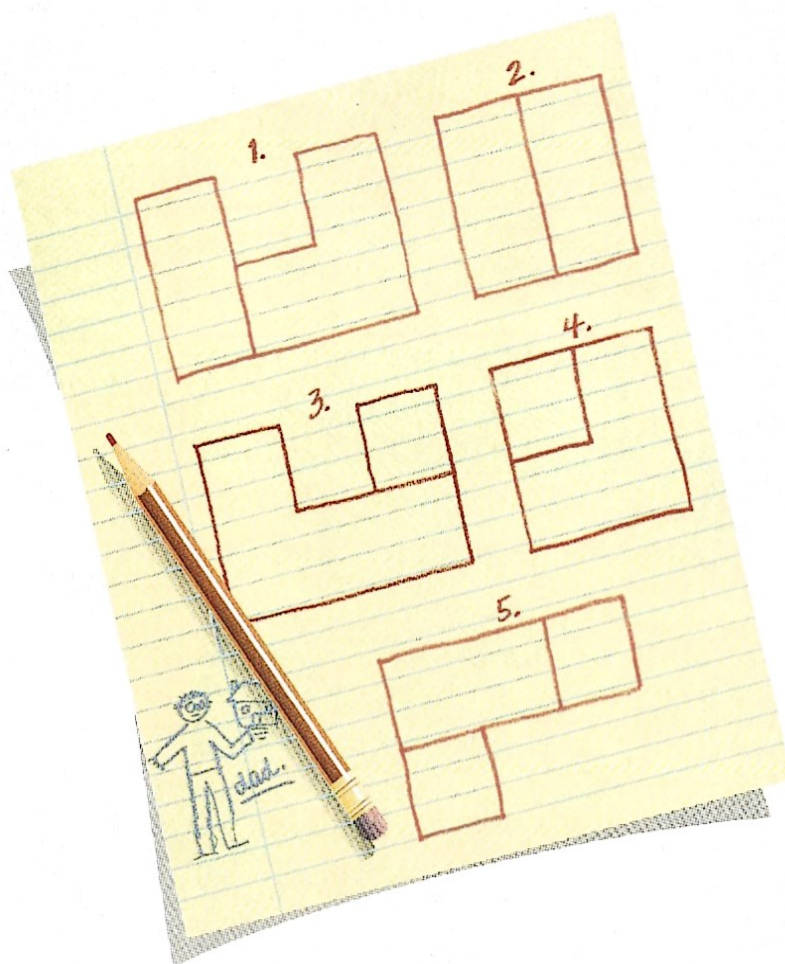


BRAIN BOGGLERS

Mental Block

BY TERRY H. STICKELS

AS AN ARCHITECTURAL ENGINEER, YOU THOUGHT IT WAS A GOOD IDEA TO GIVE YOUR child a set of blocks, in the hope that she would grow up to be an engineer like you. One day, after a stressful ten hours in the office, you come home to find her prancing around with a few sheets of paper in her hands. You try to shoo her away, but she demands that



you look at what she's done. One page shows five views of a number of the blocks put together, with interior lines indicating a change in depth. The child wants to know if you can figure out what the sixth view looks like. Can you prove you're smarter than your five-year-old? If you want to show that you're really smart, draw a 3-D image of the blocks. *(The solution is on page 107.)*

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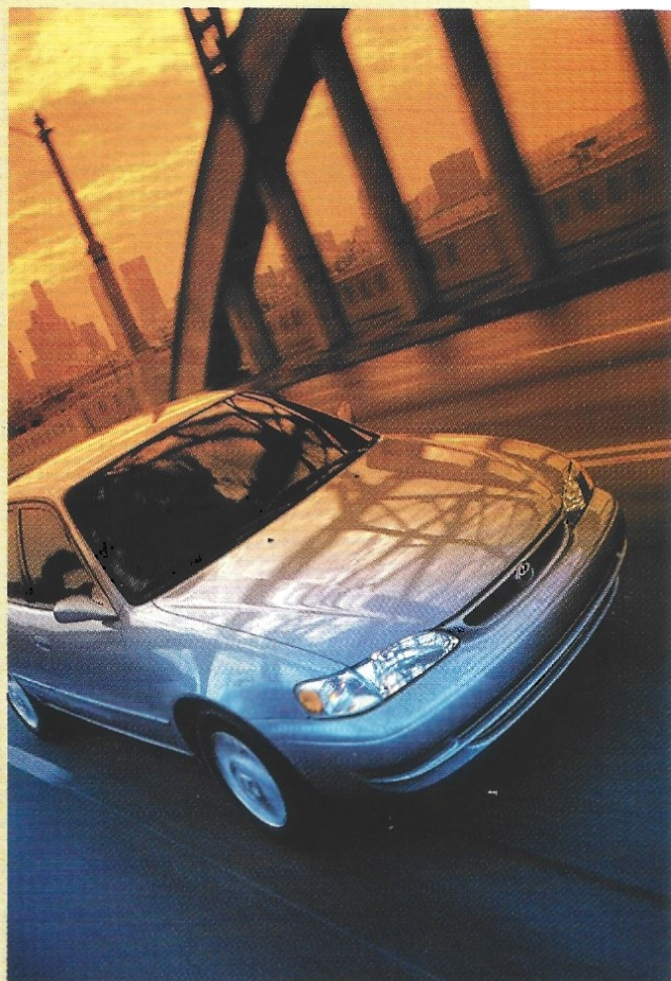
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